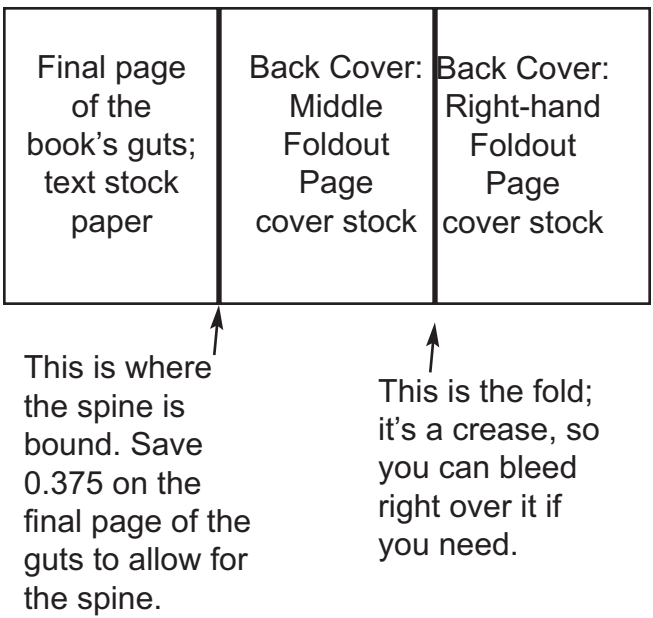
This is the last page of your book's guts. It will be on the left-hand side of your inside back cover foldout. Like this:


Final page of the book's guts; text stock paper
Back Cover: Middle Foldout Page cover stock
Back Cover: Right-hand Foldout Page cover stock
This is where the spine is bound. Save 0.375 on the final page of the guts to allow for the spine.
This is the fold; it's a crease, so you can bleed right over it if you need.

SHOUT
SHARE
IT
SECURITY

(title page)

2015 EMRA / AIRWAY●CAM

Pocket Guide to Intubation

3rd Edition

Richard M. Levitan, MD

Airway Cam Technologies, Inc.

Wayne, PA

AUTHOR
[About the author]

PUBLISHER
Emergency Medicine Residents' Association
1125 Executive Circle, Irving, TX 75038-2522
972.550.0920
www.emra.org

EMRA Staff

Cathey Wise
Executive Director

Leah Stefanini
Meetings & Advertising Manager

Linda Baker
Marketing & Operations Manager

Chalyce Bland
Project Coordinator

Valerie Hunt
Managing Editor

Disclaimer
This handbook is intended as a general guide to patient care only. The publisher, author, editors, and sponsoring organizations specifically disclaim any liability for any omissions or errors found in this handbook, for appropriate use, or treatment errors.

Copyright 2015
[Richard M. Levitan? Or Airway Cam Technologies, Inc.?]

All rights reserved. This book is protected by copyright. No part of this book may be reproduced in any form or by any means without written permission from the copyright owner.

ISBN [to come]

Table of Contents

Table of Contents

Engineering Crisis Performance: Cognition, Prioritization & Incrementalization

- Without controlling how you think, you cannot control what you do.

- It is the perception of the demand vs. the perception of your abilities that creates performance stress.

- If the perceived demands exceeds your perceived abilities, your brain triggers an adrenergic response with physiologic and cognitive effects.

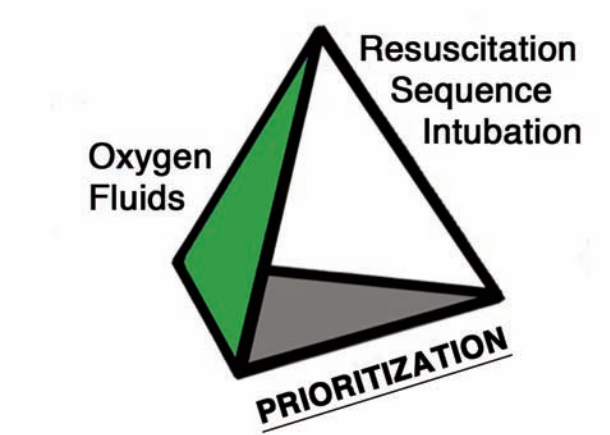
- Excessive adrenalin causes tachycardia, tremor, altered breathing, muscular tension, lack of situational awareness, loss of visual and auditory cues, and decision paralysis ("stuck on stupid").

- Mindset is how you think, how you talk to yourself, and frame the challenges of your job. Managing performance stress, self-talk, and neurolinguistics count.

- Procedural insight--true understanding and conviction in a best practice--is required for both confidence and task ownership.

- Mindisght coupled with insight lets you accept responsibility, accept reality (be objective), and perform well, even in crisis.

Prioritization



- In life and death human endeavors crisis performance and survival hinges on proper prioritization.

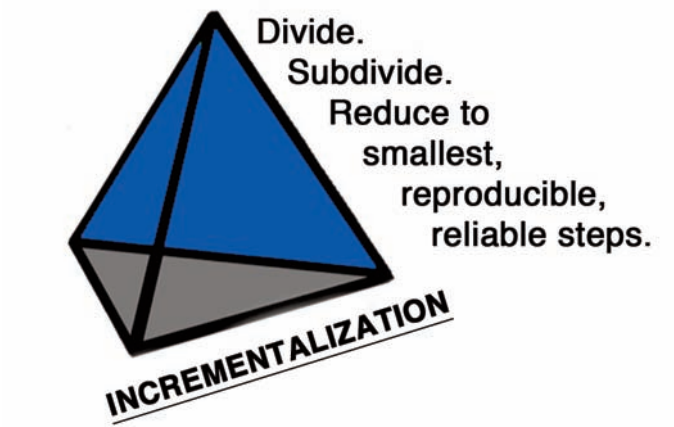
- Complicated algorithms are cognitively crippling and not realistic. Complexity is a fraud. The "big picture" is a distraction; what is required is to focus on and perform the next task.

- Oxygenation is the first priority. Hypoxia kills quickly.

- Fluids negate mask ventilation, LMA, apneic oxygenation, and every means of laryngoscopy. Each aspect of management must reduce the risk of regurgitation, emesis, and address fluids.

- Resuscitate, then intubate, patients in shock. Pharmacologic adjuncts and positive pressure ventilation have hemodynamic consequences. Oxygenation, not plastic, is the urgency in most patients. Ventilation is time dependent in severe acidosis.

Incrementalization



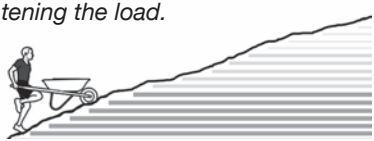
- The "secret " of competence in crisis is to break down the challenge into smaller parts, and then incrementalize it into its smallest, most fundamental components.

- Operators should master a regimented series of best-practice steps that are small, reliable, and reproducible. Expertise is the ability to do each task well, transforming incrementalized steps into one fluid, apparently easy, and effortless movement.

- Slow is smooth and smooth is fast. Rushing deteriorates performance. Multi-tasking is a myth.

- Procedures should be engineered for crisis performance, by flattening the slope, and lightening the load.

- Slope: Incrementalization
- Load: Cognition



VAPORS - Airway & Critical Care

Ventilation - Estimate pre-procedural minute ventilation and recognize the extremes of minute ventilation.
Clinical examples: COPD/asthma - low minute ventilation.
Severe acidosis: compensatory high minute ventilation.

Acidosis - Recognize severe acidosis with compensatory respiratory alkalosis. Examples: severe DKA, salicylate toxicity, acute renal failure, and rhabdomyolysis. In extreme cases it may be difficult to match patient's respiratory effort; therapy treating underlying process may need to be initiated prior to intubation.

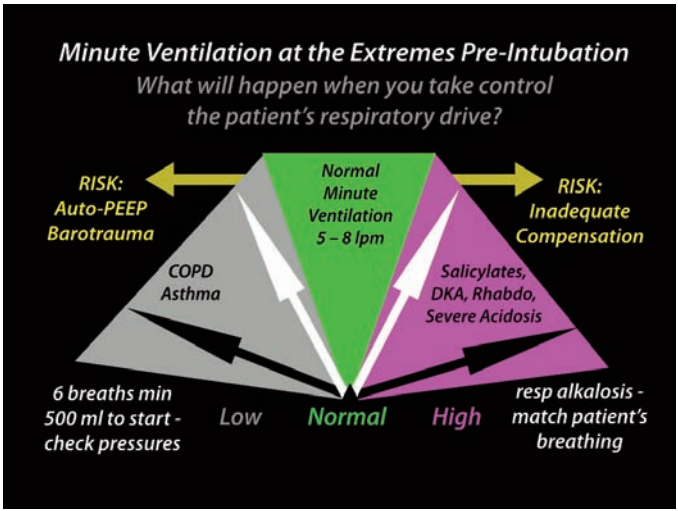
Pressures - Note pulmonary pressures & blood pressure. High plateau pressures reduce venous return. Auto-PEEP (breath stacking) can cause hemodynamic collapse. Intubation can cause life-threatening hypotension in critically ill patients.

Oxygenation - Optimize gas diffusion & absorption. Airway strategies must consider alveolar patency, oxygen gradients, safe apnea times, and need for PEEP.

Regurgitation - Overall airway strategy, positioning, and ventilation approaches must prevent emesis and regurgitation, and address handling of fluids. Decompress with NG tubes the bowel obstructed, severe upper GI bleeding patients, and others at high risk of induction associated regurgitation.

Shock Index - Heart Rate / Systolic Blood Pressure. Simple ratio for identifying patients at risk of life-threatening hyptension on induction & post-intubation (SI > 1.0). Fluids, tiitrate induction agents, avoid over ventilation, and use pressors as needed.

Ventilation

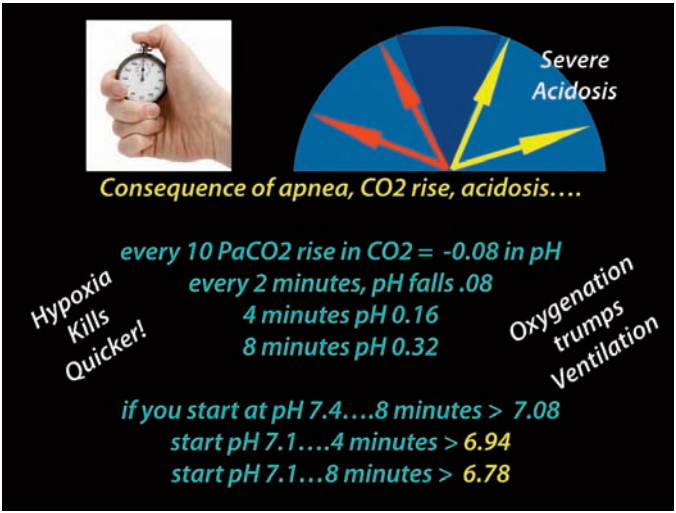

Minute Ventilation at the Extremes Pre-Intubation
What will happen when you take control the patient's respiratory drive?
RISK: Auto-PEEP Barotrauma
Normal Minute Ventilation 5 – 8 lpm
RISK: Inadequate Compensation
COPD Asthma
Salicylates, DKA, Rhabdo, Severe Acidosis
6 breaths min 500 ml to start - check pressures
Low
Normal
High
resp alkalosis - match patient's breathing

- Ventilatory extremes have much greater risk of peri-intubation clinical deterioration and cardiac arrest.

- Minute ventilation = respiratory rate x tidal volume. Normal minute ventilation is 5-8 liters per minute. A respiratory rate of 12 and a tidal volume of 500 = 6 liters minute ventilation. Non-invasive ventilation (CPAP/BiPAP) machines give minute ventilation information directly.

- At the extremes of ventilation, general goal (except in apnea) should be to match the patient's own pre-procedure minute ventilation, and then correct ventilatory abnormalities slowly as you treat underlying pathology.

Acidosis & Respiratory Alkalosis



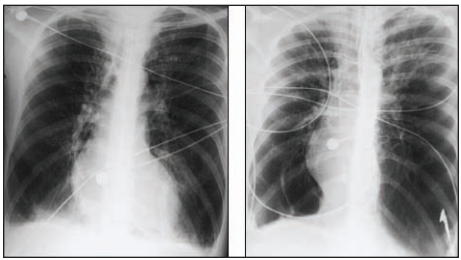
- Apnea during intubation efforts, even of several minutes, is not a problem in most patients, as long as passive oxygenation is effective and hypoxia is avoided.

- Patients wth critical hypoxemia despite oxygen (i.e. ARDS, CHF, etc.) and requiring PEEP, fast ventilatory rates, and low tidal volumes--will not tolerate apnea well. CO2 rise is dangerous in patients with increased ICP (cerebral blood flow = MAP-ICP).

- Apnea (and underventilation) during and after intubation is dangerous in severely acidotic patients with a compensatory respiratory alkalosis. Drop in pH is more precipitous in critically ill than standard formulas above suggests. Below pH of 7.0 there is risk of cardiovascular compromise.

Pressures- Airway Pressures, Blood Pressure & Hemodynamics

Hyper-inflation after intubation, compressing heart and causing life-threatening hypotension, in a COPD patient.



- Patients with severe COPD and asthma have a 10x risk of life-threatening peri-intubation hypotension. With excessive rate and volumes the underlying lung pathology prevents air egress. As the lungs expand and pressure rises, auto-PEEP ensues, venous return is compromised, and the heart collapses.

- In severe COPD and asthma set the post-intubation ventilation rate to 6 and tidal volume of 500 cc; minute ventilation = 3 lpm. Maximize your inflow rate, allowing maximal time for exhalation between breaths. Correct hypercarbia and increase minute ventilation slowly as you treat underlying disease process. Permissive hypercapnea is well tolerated if pH is kept above 7.0. Aim for plateau pressures < 30. Use ketamine drip along with standard therapies if necessary post-intubation.

- If pulse oximetry and blood pressure falls post-intubation, slow rate and volume, and check plateau pressures. Disconnect the ventilator, and press on the chest if needed. Verify depth of tube insertion. If tube is in place and disconnecting circuit does not fix the problem, assess for barotrauma and suction the tube.

Oxygenation

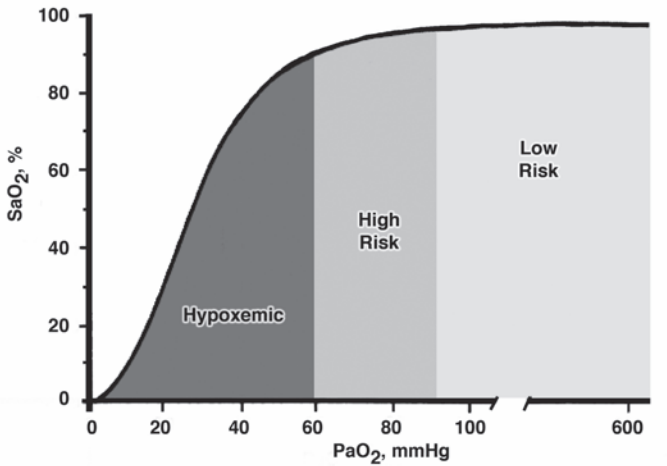
- Head forward, upright positioning, and breathing faster are the body's innate responses to hypoxia. Inspiratory flow rates in the trachea exceed the 15 lpm from standard non-rebreather masks.

- Patients naturally breathe in through their nose and out their mouth. Face masks create an admixture of exhaled CO2 and O2. Providing oxygen via the nose results in a higher FiO2 in the hypopharynx then face masks at equivalent flow rates.

- Patients pull masks off their face because: 1) they provide inadequate flow rates; and 2) they force rebreathing of exhaled CO2, which effectively lowers the delivered FiO2.

- Adding a nasal cannula to a non-rebreather or CPAP mask augments flow, boosts the effective FiO2, flushes the nasopharynx, and generally improves patient tolerance of masks.

Oxygenation



- Pulse oximetry is a poor predictor of safe apnea times.

- Patients with pulse oximetry readings in the 92-96% range on supplemental oxygen are at high risk of desaturation during intubation. Pulse oximetry in the mid 90's is immediately adjacent to the drop off point of the pulse oximetry curve.

- PEEP and supplemental ventilation (via BVM+cannula or CPAP) should be used on patients who cannot achieve oxygen saturation above 92% with supplemental oxygen.

- Nasal Oxygen During Efforts Securing a Tube (NO DESAT) provides apneic oxygenation via the nasopharynx during oral intubation, while a laryngoscope blade opens the airway.

Regurgitation

- Patients at high risk of regurgitation on induction, those with a distended stomach and small bowel, should have gastric decompression prior to intubation. Examples include the bowel obstructed and upper GI bleeders.

- Head elevation (head higher than stomach) helps minimize fluid pooling in hypopharynx and also improves oxygenation if there is fluid in the lungs. Perform laryngoscopy with suction ready.

- Time laryngosciopy after muscle relaxants to avoid jumping the gun, i.e., starting too early before full onset of muscle relaxation may trigger gagging (have person giving drugs time 60 seconds).

Shock Index

- Shock Index = HR / SBP. Shock Index > 1.0 = high risk of peri-intubation hypotension and cardiovascular collapse.

- Patients on negative chronotropic agents or in cardiogenic shock may not elevate their heart rate. Ultrasound is helpful for assessing RV function.

- Positive pressure ventilation, loss of adrenic tone, and muscular relaxation can cause hypotension with RSI. Verify good IV function and always fill the tank prior to RSI (fluids, or blood as needed). Initate resuscitation of patients in shock before RSI.

- Have push-dose pressors ready, or start IV pressors (usually norepinephrine) prior to intubation with SI > 1.0 after fluids.

~~Rapid~~ Resuscitation Sequence Intubation

- Rushing has negative effects at multiple points in emergency airway management:

1) Over ventilation prior to laryngsocopy distends the stomach increasing the risks of regurgitation and emesis.
2) Jumping the gun on blade insertion, without waiting 60 seconds after RSI meds, can trigger gagging and vomiting.
3) Inserting the blade too quickly, missing the epiglottis on insertion, leads to inability to recognize landmarks. It is the most common error of novice intubators.
4) Inserting the tube too quickly leads to esophageal placement.
5) Over ventilation post-intubation can decrease venous return and trigger hemodynamic collapse.

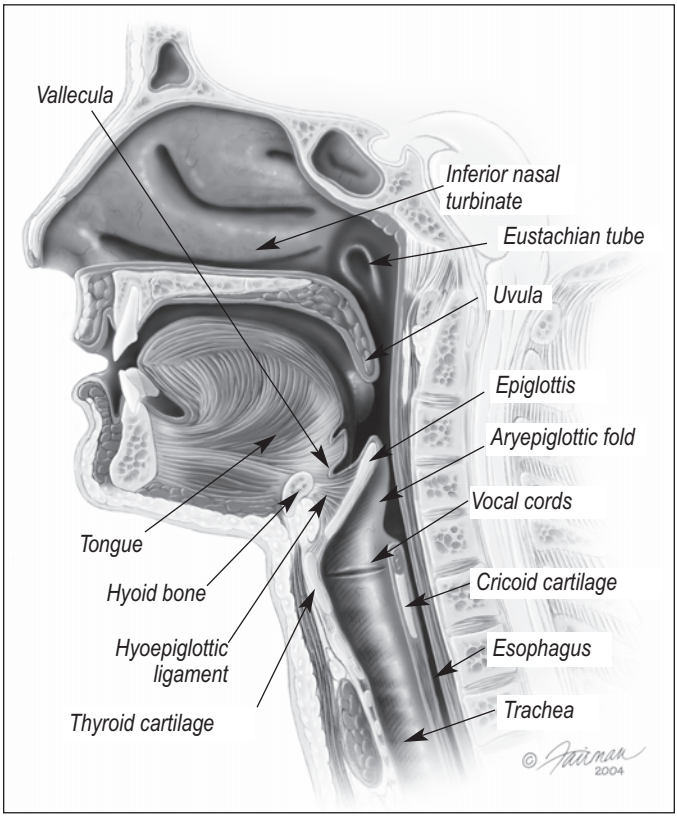
- Optimize pre-oxygenation and apneic oxygenation to prolong safe apnea--allowing for a controlled, calm, slow and smooth intubation on first pass. Performance improves if not rushed by hypoxia. Slow is smooth. Smooth is fast.

- Time laryngsocope insertion to 60 seconds after drugs (closed loop communication with RN). Grip laryngoscope with 2 fingers, and roll blade slowly down curvature of tongue, with progressive landmark exposure. Insert tube slowly. Watch tip enter glottis.

- Optimize oxygenation and fluid status prior to airway management to avoid critical hypoxia and cardiovascular collapse.

- Rapid Sequence Intubation should be replaced with the term Resuscitation Sequence Intubation. Resuscitation of critically ill patients should preceed intubation.

Anatomy- Upper Airway



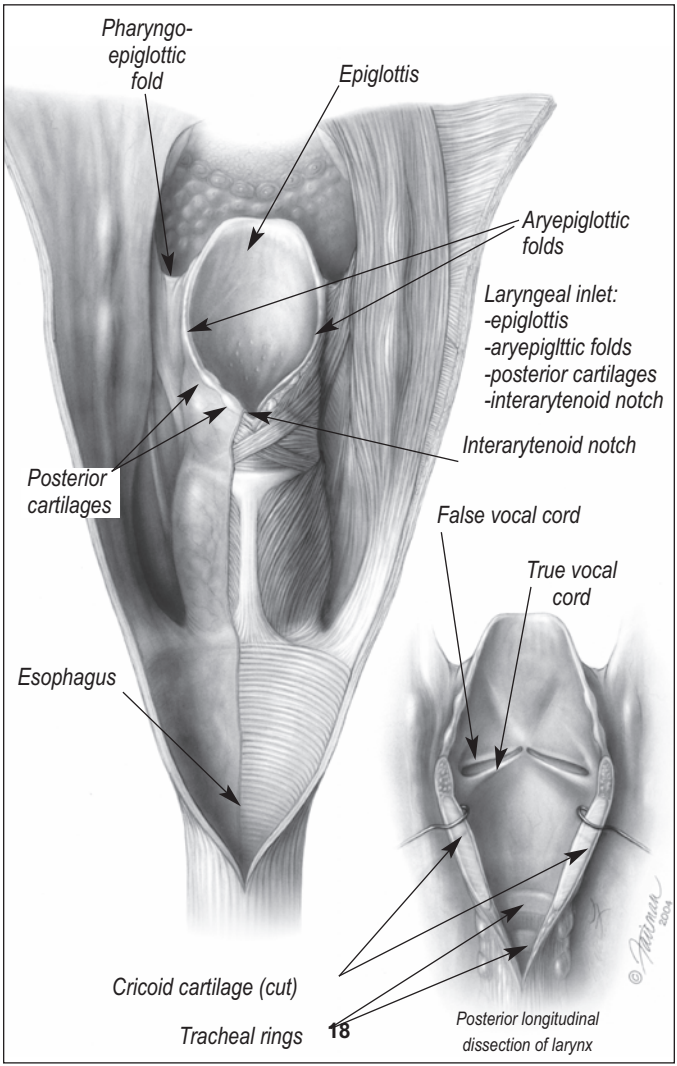
- The epiglottis is the bridge between the tongue and larynx.

- The esophagus is a flat structure behind the trachea; the larynx is in close proximity to the anterior cervical spine.

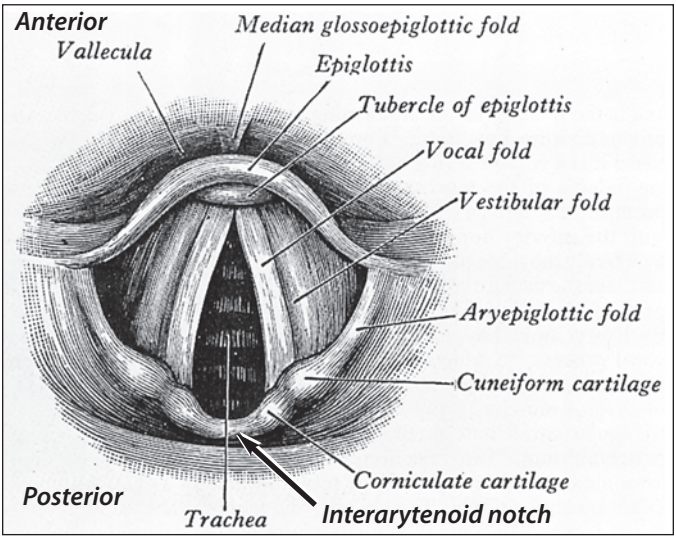
- The hyoid and hyo-epiglottic ligament suspend the epiglottis from the base of the tongue.

- The laryngeal inlet faces posteriorly. Trachea follows the spine.

Anatomy- Upper Airway



Anatomy - Larynx



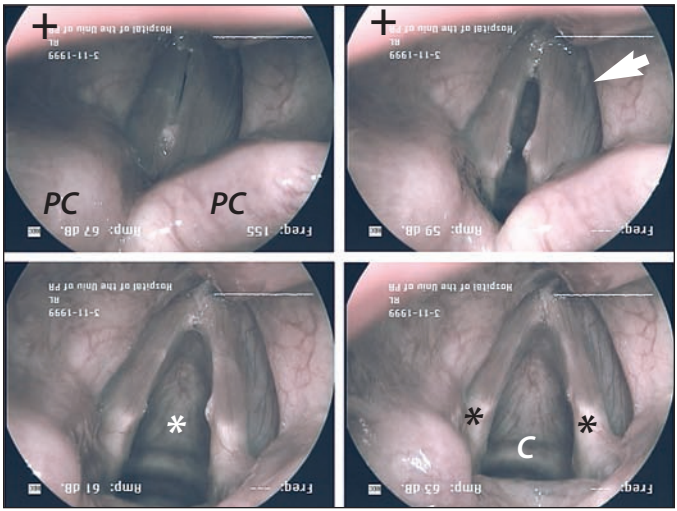
- The larynx at mirror laryngoscopy, during breathing.

- From this perspective the ring of structures making up the laryngeal inlet (epiglottis, aryepiglottic fold, cuneiform and corniculate cartilages, the interarytenoid notch) appear to be on same plane. This is not the case; the epiglottis is significantly hmore cranial than the posterior cartilages and notch.

- The true vocal cords are caudal to the false cords, and the false cords are caudal to the arytepiglttic folds.

- The posterior cartilages, a.k.a., the arytenoids, are located at the top of the cricoid cartilage.

Anatomy - Larynx

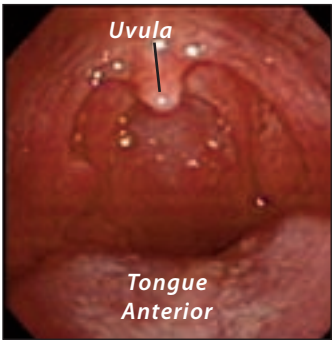


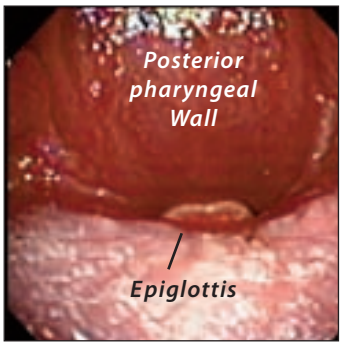
- Stroboscopy combines a flashing light with a microphone capturing the vibrations of voice. This allows increadible imaging of the laryn during all phases of phonation and breathing. The vocal cords and posterior cartilages come together during phonation (top left), and open during breathing (bottom right).

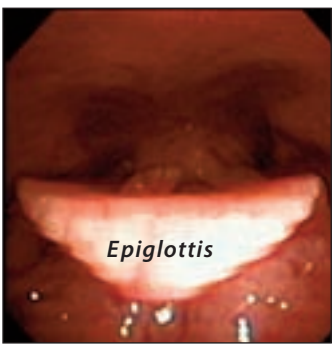
- Solid white arrowhead is the false vocal cord (top right) , which is just a mucosal fold lateral to and more cephalad than the true vocal cords (black asterisks). PC = posterior cartilages (top left). The epiglottis is marked by a black cross (top images).

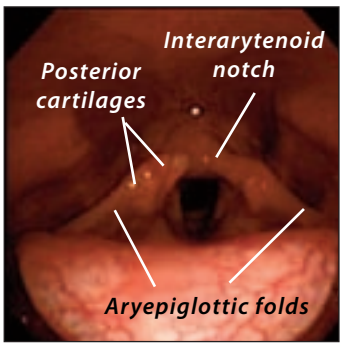
- The cricothyroid membrane, seen from above, is marked by the black asterisk in lower left image. Note the large cricoid ring, marked "C". It is more prominent than the tracheal rings below.

Anatomy - Video Endoscopy

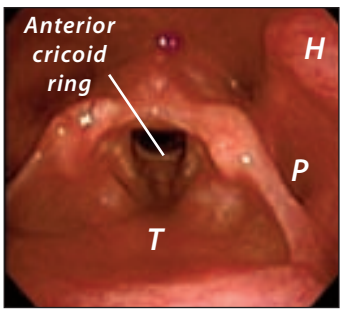




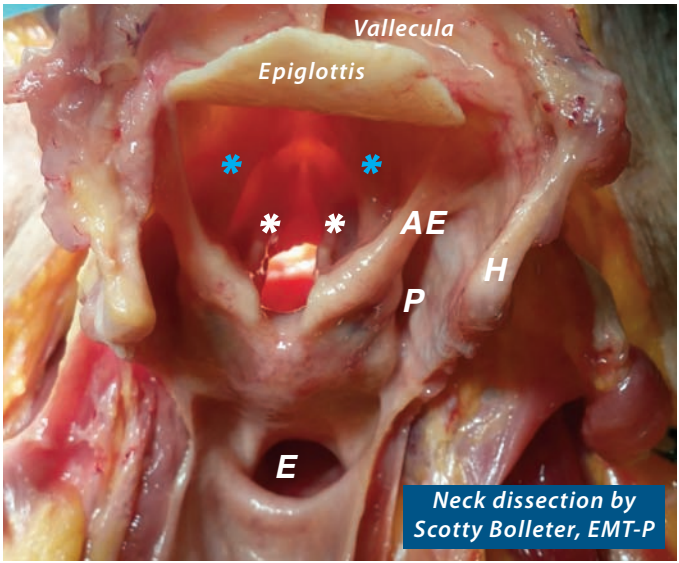




- Progressive landmarks during high-resolution endoscopy.
- Perspective is facing patient; tongue, epiglottis are below (anterior), posterior cartilages and esophagus above.
- "H" marks internal hyoid prominence, "T" the tubercle of the epiglottis, "P" = pyriform.



Anatomy - Surgical Exposure in Cadaver



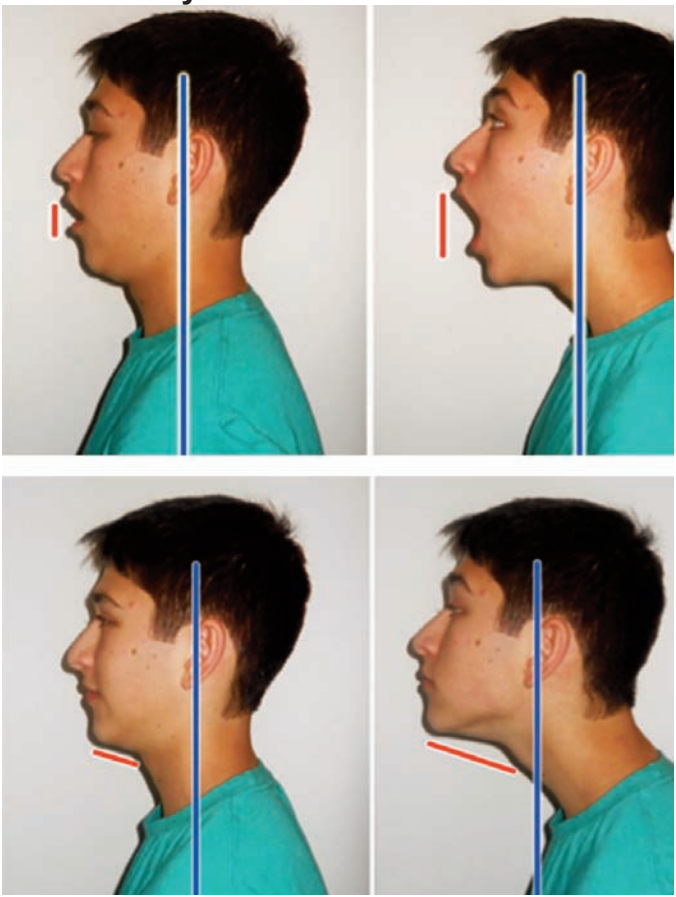
- Looking from above at exposed larynx and esophagus after a horizontal surgical incision below the level of the mandible.

- The cricothyroid membrane has been incised and is the bright light at center of image seen between the vocal cords.

- The true cords are marked with white asterisks, the false cords blue asterisks.

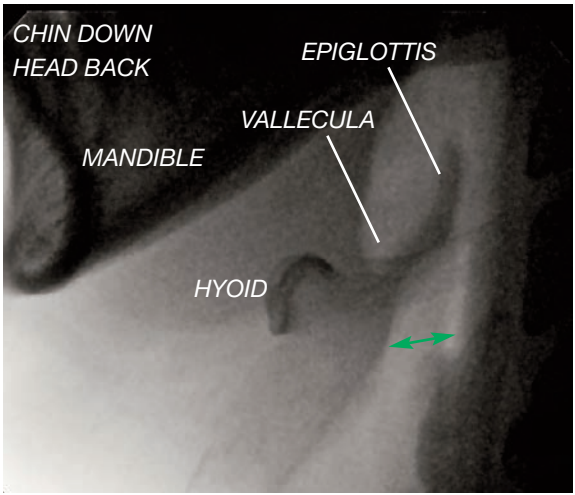
- "H" = hyoid (right), which curves in a horseshoe shape around the base of epiglottis, "E" = esophagus. AE = aryepiglottic fold (right). P = pyriform sinus (right) .Between the esophagus and interarytenoid notch is the broad, flat back wall of the cricoid.

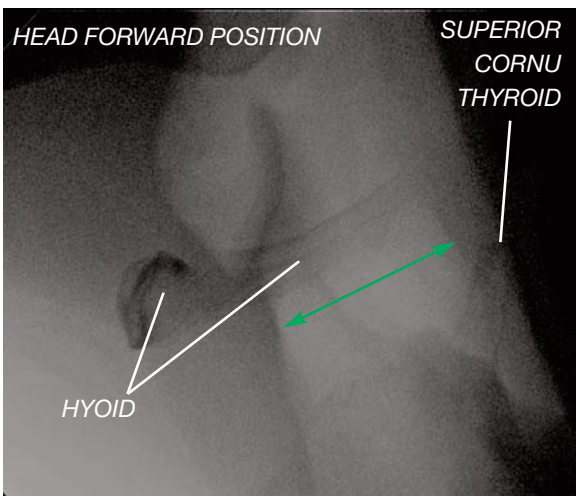
Anatomy - Mouth & Neck Mechanics



- Head forward, ear-to-sternal notch positioning (right)
- Increases mouth opening and the thyromental distance, which is the space for displacing the tongue while performing airway maneuvers in the mouth. Also straightens the cervical trachea.

Anatomy - Mouth & Neck Mechanics





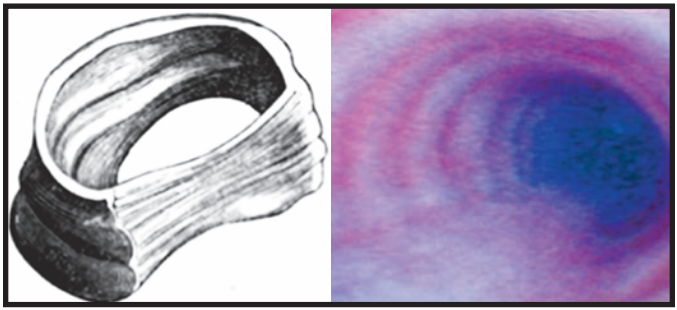
Anatomy - Mouth & Neck Mechanics

-Radiographs comparing positioning: atlanto-occipital extension (top left), chin down and straight head position (bottom left), vs head forward, ear-to-sternal notch position (right). A tracheal tube is in the nasopharynx and just above the larynx.

- Bringing the head forward expands upper airway dimensions, and aligns the upper airway to the cervical and thoracic trachea.

- Notice here and on p. 24 how close laryngeal structures are to the cervical spine; the larynx has mobility side to side, not back.

Anatomy of the Trachea



- Understanding the anatomy of the trachea is important when addressing tube insertion problems.

- The diameter of the trachea average 15-20 mm in males and 14-16 millimeters in females.

- Tracheal tube insertion can be mechanically impeeded by the corrugation of the trachea (the tracheal rings), and the posterior inclination of the trachea, which follows the thoracic spine.

- Standard tracheal tubes have an asymmetric left bevel, and a leading edge that impacts on the anterior tracheal rings.

- Stylets add stiffness to the tube and often are shaped with long axis dimensions that exceed the dimensions of the trachea.

- The membranous trachea is flat and abuts the esophagus. Objects in the esophagus can cause airway occlusion of the trachea by pressing into the membranous trachea.

Apneic Oxygenation

- Oxygen absorption is dependent on an oxygen gradient, open alveoli, hemoglobin, and forward blood flow. It continues even without movement of the diaphragm, i.e., even during apnea.

- Apneic oxygenation has only recently been included in ACLS protocols, but it has a long history in anesthesia, ENT and thoracic surgery.

- Due to the differences in oxygen absorption (250 ml per minute, driven by hemoglobin binding and forward blood flow) and CO2 diffusion (into alveolar space at only 10 ml per minute), there is a negative pressure in the alveolus during apnea. This negative pressure (-240 ml) draws O2 down the trachea during apnea.

- CO2 builds up during apnea, at approximately 3-5 mm/Hg per minute. This is rarely consequential during airway management, except in situations of extreme acidosis with compensatory respiratory alkalosis. It can also be consequential in patients with increased intracranial pressure.

- Apneic oxygenation does not work well when alveoli are collapsed, i.e. flat positioning in morbidly obese patient, and in ARDS, improve laryngeal exposuresevere CHF, or other situations when ventilation with PEEP is necessary to stent open the alveoli.

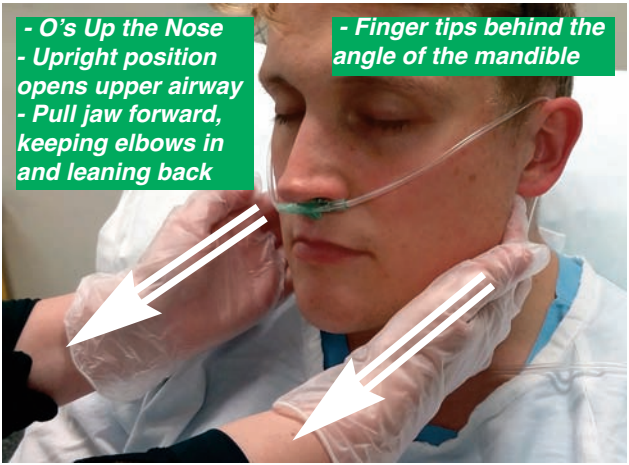
Response to Hypoxia:
Patient Flat is the Coffin Position!

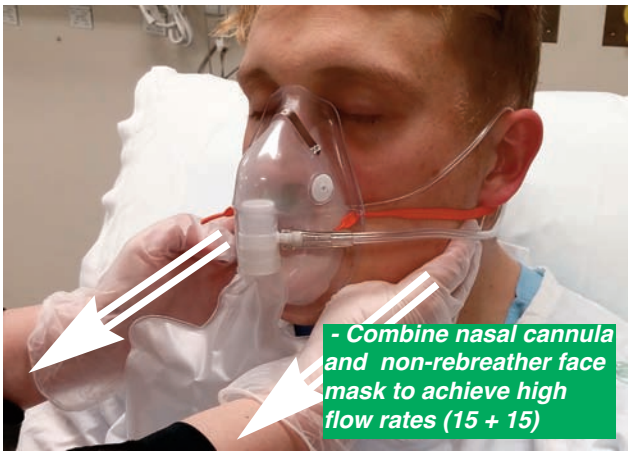
- Flat positioning has multiple negative impacts on oxygenation and increases the risk of regurgitation:

1) The tongue and epiglottis fall backwards, creating upper airway occulsion.
2) Dependent alveoli are compressed.
3) Total lung volume is diminished.
4) Diaphragmatic excursion is impacted by abdominal contents
5) The stomach, esophagus, and oropharynx are at the same level, promoting regurgitation of stomach contents as muscular tone is lost.

- Mask ventilation is very challenging for a single operator. Even with assistants, pressing the mask down on the face to create a seal pushes the the mandible posteriorly creating obstruction.

Incrementalized Response to Hypoxia: Oxygen On, Pull on the mandible Sit the patient up: OOPS


- O's Up the Nose
- Upright position opens upper airway
- Pull jaw forward, keeping elbows in and leaning back
- Finger tips behind the angle of the mandible



Incrementalized Response to Hypoxia: Bagging Upright, with PEEP valve and Nasal Oxygen under BVM

1) Upright position expands lung volume and alveoli
2) Upright position allows for diaphragmatic excursion
3) Upright position lessens risk of passive regurgitation
4) O's up the nose stents open the airway
5) O's up the nose provides continuous flow of oxygen even when not squeezing bag (apneic oxygenation)
6) PEEP valve on BVM helps alveolar expansion, O2 absorption
7) Base of tongue and epiglottis are pulled forward
8) Seal at base of mask is provided by the operator distracting the mandible. Thumbs press down against mask while fingers pull on mandible--easy mechanism for creating a tight seal, without posterior directed force on mandible (obstructing airway).

O's up the Nose & The Nasopharynx: The Fire Door of the Airway

-The nose is the natural and better route to oxygenate and to ventilate than the mouth.

- Blowing oxygen into the nasopharynx stents opens the airway--it acts like a fire door-- it opens as it gets pressurized. The mouth is an an inward opening fire door--it collpases on pressurization.

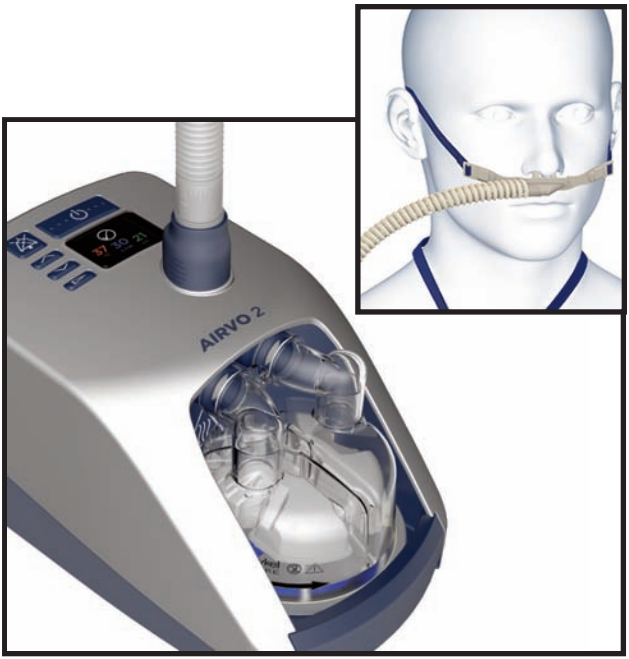
O's up the Nose & The Nasopharynx: The Fire Door of the Airway

- The nose is direct and straighter route of gas flow to the trachea.

- The nasopharynx is an oxygen reservoir that fills with nasal cannula oxygen during exhalation.

- The nasopharynx is the naturally patent airway, even in obese patients.

High Flow Nasal Cannula



- High Flow Nasal Cannula systems combine adjustable flow rates and adjustable FiO2, with humidification. They are much better tolerated than CPAP facemask systems.

- Flow rates can be as high as 90 lpm. Rates above 30-40 liters help overcome the work of breathing significantly. Flow rates of 70 lpm have been shown to provide apneic oxygenation and even effective ventilation.

- High flow rates also provide a small measure of PEEP.

Mask Ventilation in Supine Patient

- Bagging in an ear-to-sternal notch position is better than bagging flat. Bagging upright is best. Tlit foot of bed down to lower stomach, improve diaphragmatic excurison. Add nasal cannula and PEEP to all BVM efforts [not shown here].

- Operator should use only one hand under bag, squeezing bag slowly (1-2 seconds), and using low volume (half the bag) and low rate (6-8 per minute). [Cases of compensatory respiratory alkalosis require higher minute ventilation.]

- Second operator should focus on creating a face-mask seal and pulling up on mandible.

Supraglottic Airways (SGA's): Redefining Elective Anesthesia & Rescue Ventilation

- "Supraglottic airways" refer to airway devices that create an airway seal above the glottis.

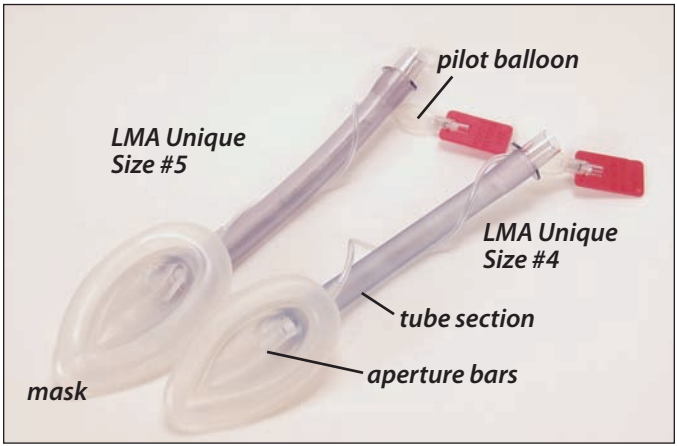
- LMA type devices have a wedge shaped mask, the tip of which fits behind the cricoid cartilage, in the upper esophagus. The soft tissue above and around the larynx collapses onto the mask. The seal comes from how well the mask mirrors the patient's airway anatomy; it is not a function of how much air is in the mask. Over-inflation causes the mask to be stiffer, worsening the seal, and compromising performance. Seal pressure is not related to cuff pressure. LMA devices have lower seal pressures (max ~25 mm Hg) than a tracheal tube or two balloon device.

- The Combitube and the King Laryngeal Tube are supraglottic airways that seal the hypopharynx with one balloon, and the esophagus with a smaller, second balloon. Between the two balloons are ventilation holes, overlying the larynx. Seal pressure with these devices is related to cuff pressure.

- SGA's work in 95% of cases of impossible mask ventilation. They work well in supine patients without muscular tone, and also in obesity (unlike mask ventilation).

- Muscle relaxants--generally chosen to improve laryngoscopy conditions--also improve mask ventilation, and permit SGA insertion without the risk of vomiting. All SGA's require an absent gag response. Over-ventilation through SGA's can cause stomach distention and regurgitation.

Laryngeal Mask Airway



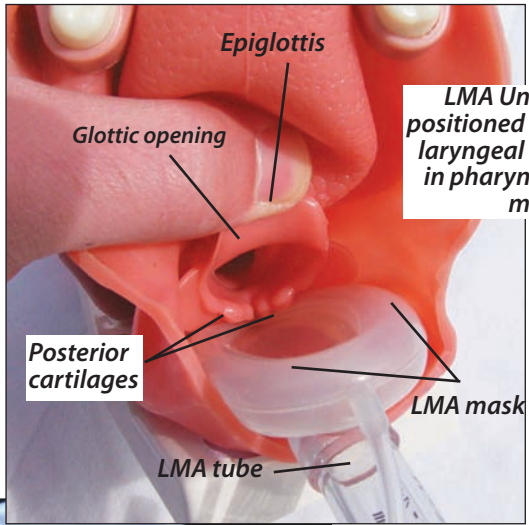
- The Unique is the single use version of the original LMA design. It is a "first generation" LMA device. It has a long airway tube, a a flat mask, aperture bars, and no gastric decompression port.

- The Aintree catheter is a tube introducer that fits over an endoscope that is used to intubate with a standard LMA. It is passed through the LMA into trachea, the LMA removed, and then a tube can be railroaded into the trachea.

- There are numerous insertion technqiues; for novice and infrequent users, the simplest method is to chose a size 4 for all adult patients, inflate the mask with 15 cc, and insert it around tongue, aiming it posteriorly on insertion.

- Best perfomance happens with half-inflation. The LMA provides rescue ventilation in 95% of mask ventilation failures.

Laryngeal Mask Airway



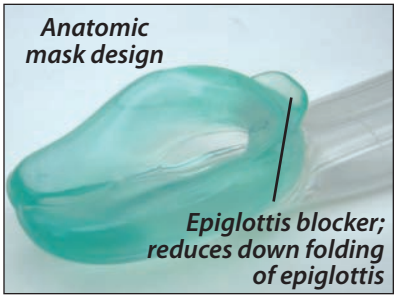
LMA type devices wedge into upper esophagus, mask faces anteiorly, and larynx collapses backward onto mask.

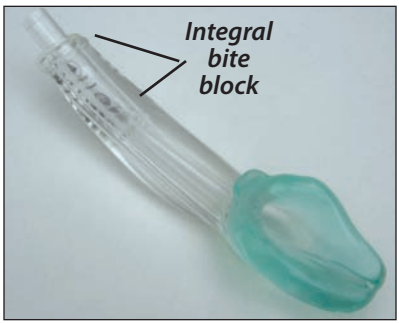
LMA tube

LMA mask

Trachea

I-Gel LMA-type SGA without a Cuff



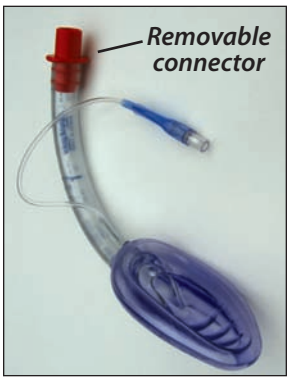


- The I-Gel has a sophisticated anatomic mask design, that does not use a cuff, but instead is made of a thermoplastic elastomer that adapts to the patient's anatomy.

- It's broad flat back helps guide it to proper positioning and it has more lateral stability than the LMA. It has a gastric decompression channel and comes with a small gastric tube.

- Sizes are equivalent to an LMA, i.e. size 4 for most adults, a #5 for large men. Size #3 for very small adults.

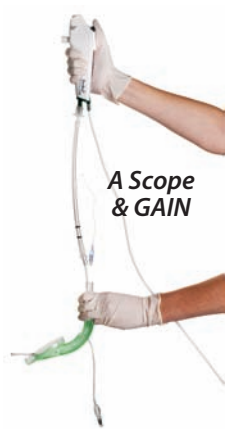
Air-Q LMA-type SGA



Mask and keyhole airway outlet

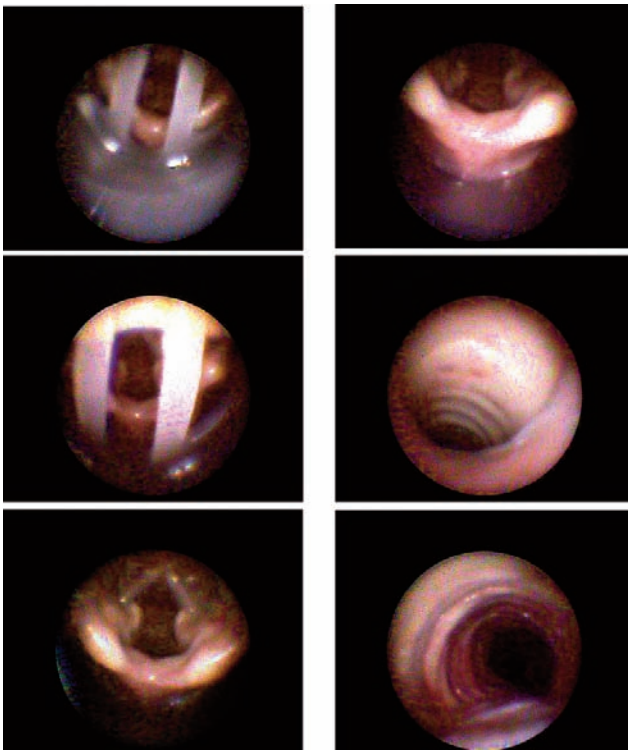
- The Cook Gas air-Q is a second generation LMA type device that like the I-gel has a sophisticated bowl design, and has the capacity to intubate directly through the device (using an endoscope). It also comes in versions with a self-pressurizing mask or an esophageal block.

AMBU Aura GAIN LMA-type SGA



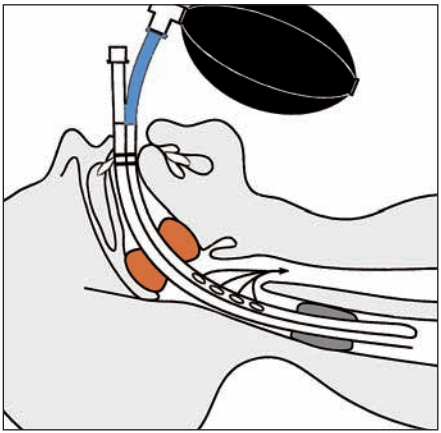
- The Aura GAIN is an LMA type SGA designed for endoscopic intubation (single-use A scope shown) that also provides gastric decompression.

Endoscopy Through the LMA



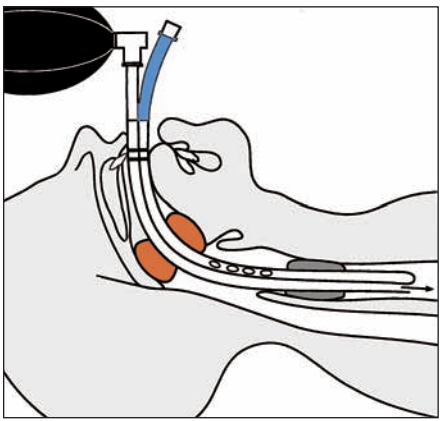
- To understand how an LMA type device fits, it's very useful to see it in situ, through an endoscope. Top left image shows the mask tip (inferior, grey color) going under posterior cartilages, into upper esophagus. The aperture bars of this LMA Unique overlie the larynx. Subsequent images show landmarks as the endoscope moves through glottis and into the trachea.

Combitube - Two Balloon Supraglottic Airway



Combitube in esophagus. Ventilation through lumen #1 (blue).

Device is available in Adult and Small Adult (SA) sizes. Use SA size for most adults (less than 6.5 ft tall).

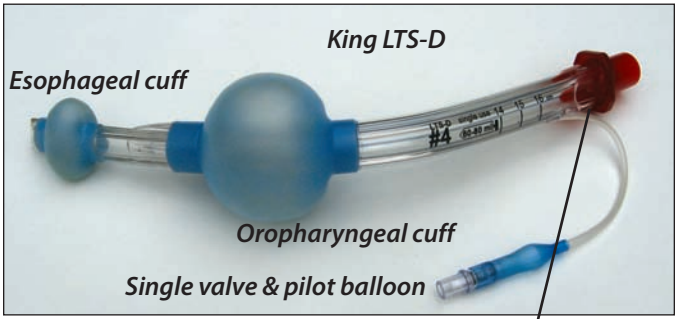


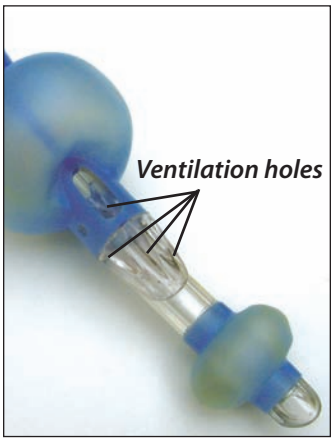
Combitube in trachea. Ventilation through lumen #2 (clear).

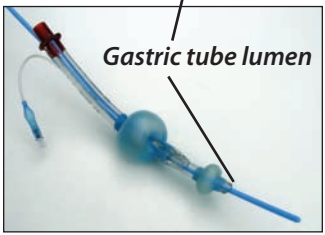
Operators must check end tidal CO2 and verify location in all patients.

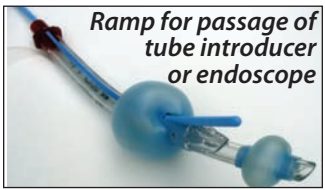
- The Combitube is the original 2 balloon device, with 2 lumens and separate ventilation ports. Intended placement is in esophagus (shown top). SA size (small adult) is best for most adults.

King Laryngeal Tube - Two Balloon SGA



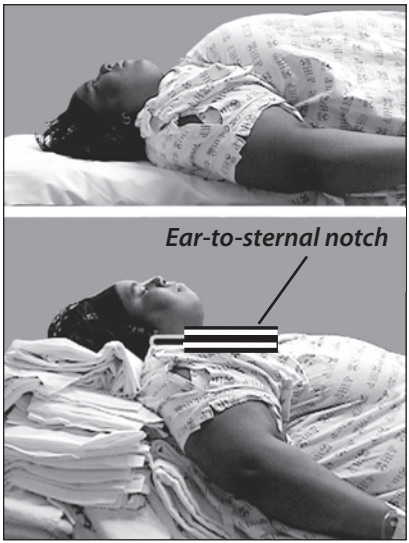






- Similar design to Combitube, but shorter length. Balloons are much softer and share a single inflation port. There is only one ventilation port. This reduces risk of catastrophic error (ventilating wrong lumen). Insert device fully, inflate balloons, and then withdraw, veriyfing good ventilation. Recommended to use only the LTS-D version (shown above) with a gastric tube lumen.

Positioning for intubation



- Head elevated laryngoscopy position aligns ear-to-sternal notch.

- Multipe benefits for ventilation and laryngoscopy.

- In C-spine immobilized (and others),tilt foot of bed down. This lowers stomach relative to mouth, and improves pulmonary function.

Head Elevation to Improve Laryngoscopy

- Dynamic lifting of the head improves laryngeal exposure, as shown above. Increasing head elevation permits greater mouth opening, expands the displacement space, and improves alignment.

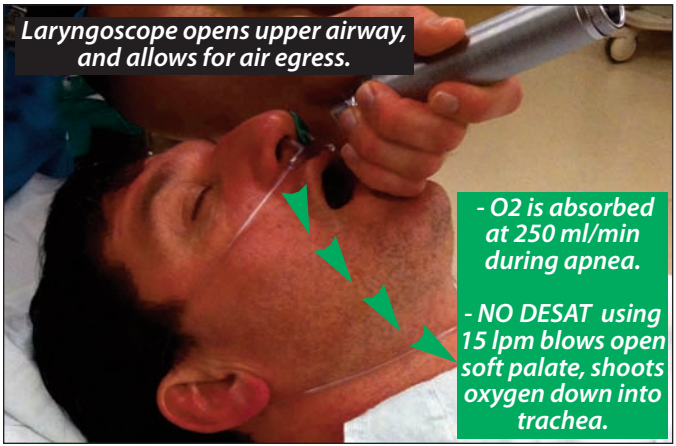
-While slight head elevation is probably safe in cervical spine immobilized patients, dynamic head elevation is contra-indicated if there is a major concern for spine injury.

- It is not possible to dynamically lift the obese patient; proper positioning must be done up front. This is best accomplished by using a massive amount of sheets and towels (shown on preceeding page) or by using stretch to elevate head--but you will still need to bring head forward relative to chest.

- It is best practice to always start laryngoscopy (direct or video) with the patient in ear-to-sternal notch alignment.

- Dynamic lifting cannot be done if the patient is positioned too high relative to the operator. The patients head should be at the position of the operator's belt--not xiphoid, which would prevent any additional head elevation if required.

Pre-Oxygenation & NO DESAT: Nasal Oxygen During Efforts Securing a Tube


Laryngoscope opens upper airway, and allows for air egress.
- O2 is absorbed at 250 ml/min during apnea.
- NO DESAT using 15 lpm blows open soft palate, shoots oxygen down into trachea.

- Blowing O's up the nose--a.k.a., NO DESAT--during laryngoscopy (direct or video) prolongs safe apnea and decreases the incidence of hypoxia during intubation.

- NO DESAT can be done with standard nasal cannulas, but does not work well with cannulas designed for CO2 detection, as the have a smaller diameter at the nares (limiting flow).

- Use 4-6 liters as part oif pre-oxygenation in the wide awake, non-critical patient; 15 lpm if the patient critically is hypoxic. Turn up the flow to 15 lpm on induction. In children -- 1 lpm/kg.

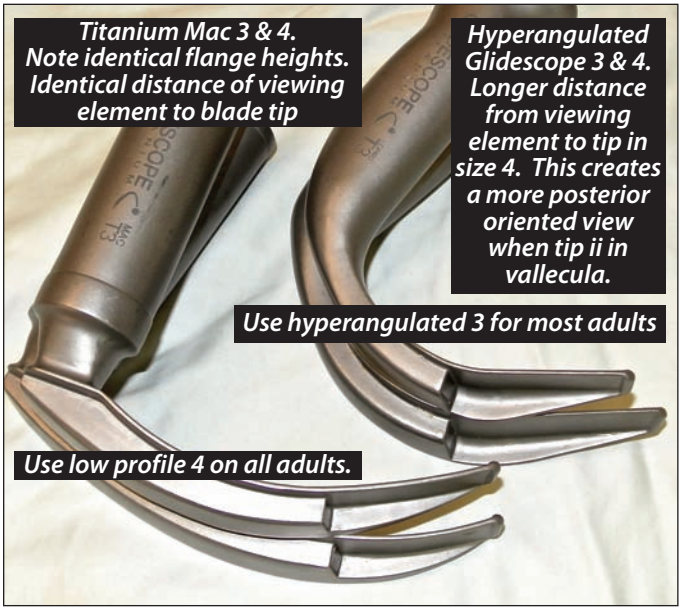
- You need 2 oxygen sources: 1 for BVM (or other mask), and 1 for nasal cannula. If necessary use portable tank below stretcher.

Direct Laryngoscopes
Macintosh & Miller Designs

- Conventional direct laryngoscopes come in two major types, curved and straight, though there are many design and performance differences related to method of illumination, dimensions of blade, location of light, etc.

- Low flange height designs (i.e., English or German) as opposed to an American Mac, have many advantages: a smaller flange so less teeth impaction, ability to use one size in all adults (Mac 4), and better illumination (shorter light-to-tip distance).

Video Laryngoscopes - Glidescope


Titanium Mac 3 & 4.
Note identical flange heights.
Identical distance of viewing element to blade tip
Hyperangulated Glidescope 3 & 4.
Longer distance from viewing element to tip in size 4. This creates a more posterior oriented view when tip ii in vallecula.
Use hyperangulated 3 for most adults
Use low profile 4 on all adults.

- Many manufacturers offer both hyperangulated designs (Glidescope Titanium standard blades on right) as well as conventional Mac designs (Glidescope Titanium Mac, above left).

- Notice that the flange heights on video Mac 3 and 4 above are same; the viewing elements are also at same place relative to tip. The author advocates a low profile video Mac for all patients.

- Hyperangulated blades have some advantages in patients with severe mobility issues, and require less blade insertion than a Mac design, but they often have more difficult tube delivery.

Video Laryngoscopes - Storz C-Mac System

- Storz pioneered video laryngoscopes with a conventional Macintosh blade design, the C-Mac.

- Interchangeable video cartridge can fit into a myriad of blades including hyperangulated "D" blade and infant straight blades.

- Platform and monitor (top) now also includes endoscopic options, including both short rhinolaryngoscopes (30 cm) and longer intubating bronchoscopes (60 cm).

Video Laryngoscopes with Integrated Monitors: McGrath & King Vision

- The McGrath Mac (left) has both standard geometry Mac blades (2,3,4) and hyperangulated blades (X blade, yellow, 3, 4).

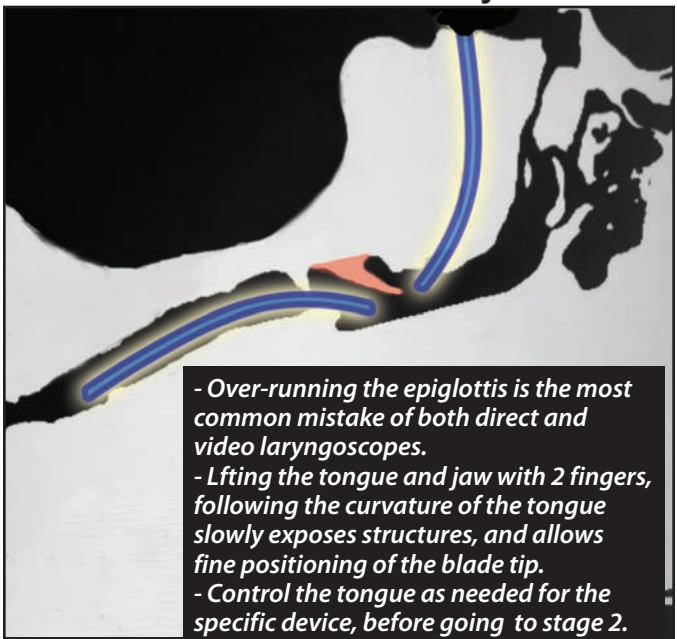
- King Vision (right, one size) has an L-bend shape; it comes with and without a channel for tube delivery. Channeled version is shown here. Tube is preloaded into channel (no stylet) before insertion; it is then slid down channel into trachea under vision.

Epiglottoscopy - 2 Finger Grip

- Best practice for direct and video laryngoscopy is largely the same:
1) epiglottoscopy
2) progressive landmark exposure
3) bimanual laryngoscopy
- Oxygenation, positioning, NO DESAT, are identical.

- 2 finger grip on laryngoscope, follow curvature of blade midline down the tongue, uvula points to epiglottis, use light force until larynx identified. Bimanual and head elevation, as needed, for improving laryngeal view.

Epiglottis - Mechanical & Antomic Center of the Airway

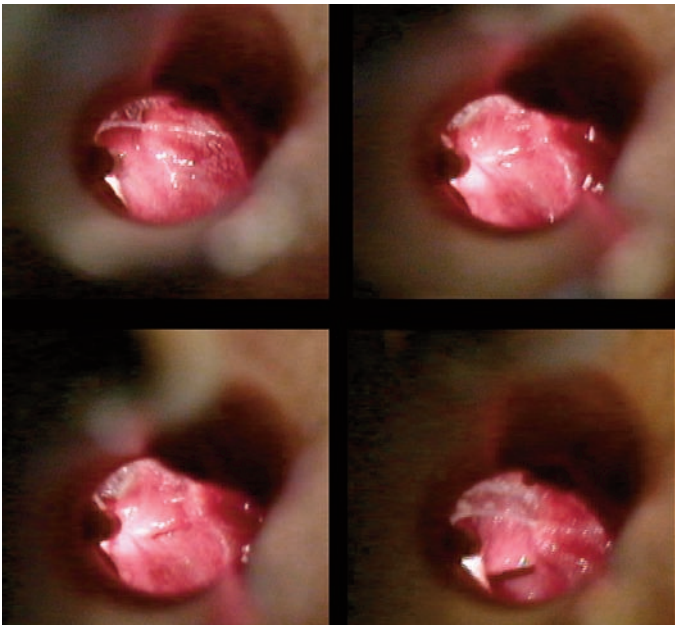

- Over-running the epiglottis is the most common mistake of both direct and video laryngoscopes.
- Lfting the tongue and jaw with 2 fingers, following the curvature of the tongue slowly exposes structures, and allows fine positioning of the blade tip.
- Control the tongue as needed for the specific device, before going to stage 2.

- There is only one secret to making laryngoscopy and every intubation a reliable, non-stressful procedure--find the epiglottis on blade insertion, whether with direct or video laryngoscopes.

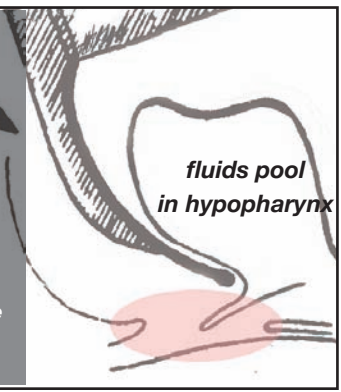
- The epiglottis is the mechanical center of the airway, between the curve of the tongue and the curve of the cervical trachea.

- The epiglottis is the anatomic center of the airway, connecting the tongue (where we start) to the top of the larynx, our goal.

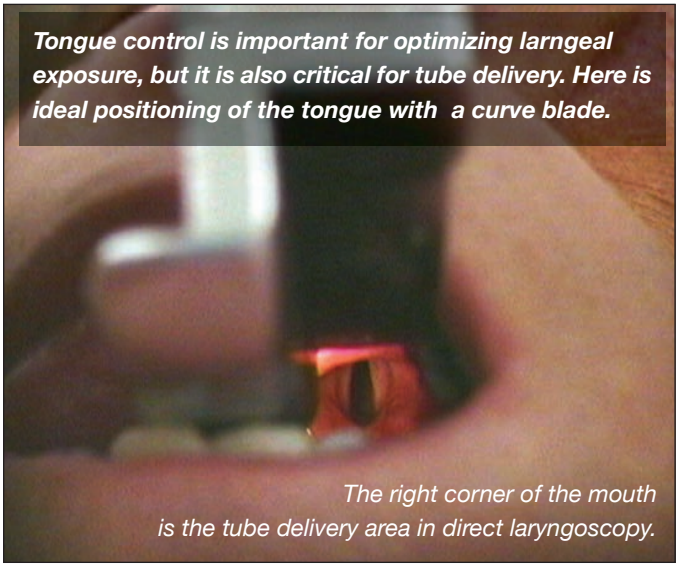
Epiglottis Camouflage

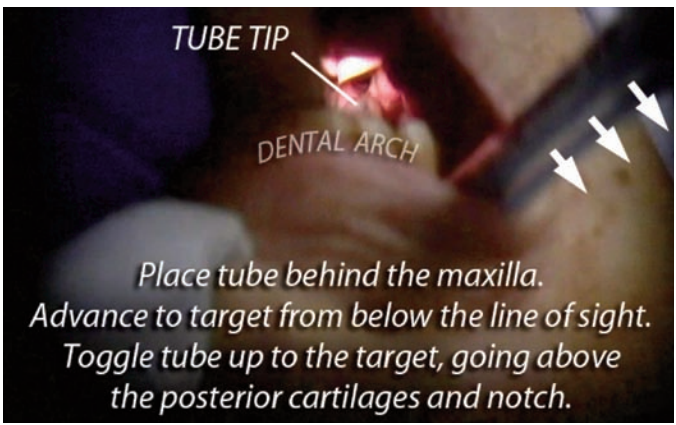


- The epiglottis matches the mucosal appearance of the posterior pharynx.
- Move slowly down the mid-line tongue, suctioning the posterior pharynx, to the uvula and palatal arch, lifting the tongue and jaw.
-Watch for the horizontal edge of the epiglottis.

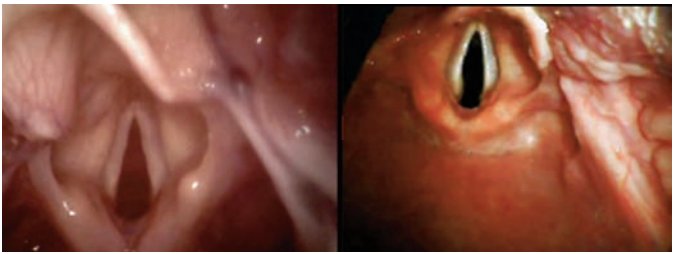


Controlling Tongue - Conventional Blades
The Right Corner - The Pivot Area of Mouth


Tongue control is important for optimizing larngeal exposure, but it is also critical for tube delivery. Here is ideal positioning of the tongue with a curve blade.
The right corner of the mouth is the tube delivery area in direct laryngoscopy.


TUBE TIP
DENTAL ARCH
Place tube behind the maxilla.
Advance to target from below the line of sight.
Toggle tube up to the target, going above the posterior cartilages and notch.

Hyperangulated Blades: Tongue Control, Tube Delivery & Preventing Injury on Tube Insertion



- Conventionally shaped video laryngoscope blades (Glidescope Titanium Mac, Storz C-Mac, and McGrath Mac) are positioned identically to direct laryngoscopy (i.e., p. 54, top image). Start with a midline approach and a light touch to find epiglottis, then after epiglottoscopy, move to control tongue, by gently moving blade to the right, and sweeoing tongue to left side of mouth. This frees right corner of mouth for tube deilvery, which is the only place possible to pivot a narrow, straight-to-cuff stylet/tube.

- Hyperangulated blades (Glidescope, Storz D-blade, McGrath X blade, King Vision) are introduced the same way--with a mid-line approach coming down the tongue and a light, 2 finger grip. After the larynx is found, however, hyperangulated blades stay midline. Tube delivery follows the blade down to larynx.

- Ideal positioning of a hyperangulated blade has the larynx in alignment with the blade axis, and the larynx at the top half of the video monitor. This permits visualization of the styletted tube as it follows the blade down, in the lower part of the screen. Inserting a styletted tube blindly (off screen) can cause injury.

Stage 2 Grip of Laryngoscope
The Blade as an Extension of the Forearm

- After epiglottoscopy, and the tongue has been controlled, the next step in laryngoscopy is optimizing laryngeal exposure. This requires more force than the first stage of the procedure.

- Switch from a 2 finger grip to gripping the handle where it meets the blade. Point your thumb up the handle.

- A low grip and thumb up positioning permits fine control.

- The blade should be an extension of your fore-arm.

- Keep your elbow close to your torso, and lean in to transmit force down the blade, with minimal use of your deltoid.

Bimanual Laryngoscopy - Integral to Development of Laryngoscopy

Czermark: Mirror laryngoscopy

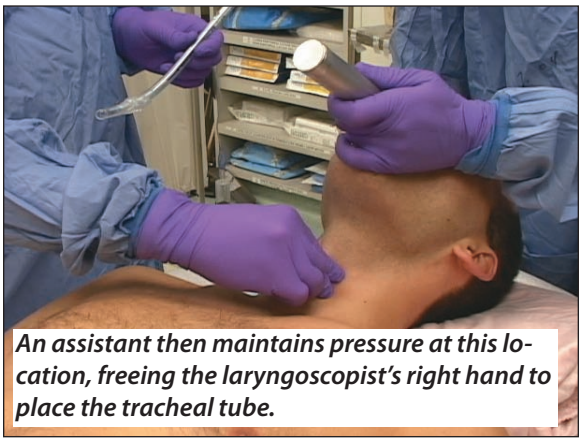
- The mobility of the larynx, and use of two hands to optimize laryngeal exposure has always been integral to laryngoscopy-- whether with a mirror, direct laryngoscope, or now with video laryngoscopes. Bimanual laryngoscopy can move the larynx posteriorly into the line of site, and has dramatic effects on indirect epiglottis elevation.

Brunnings: early direct

- As shown in these images, and true with direct laryngoscopy today, the larynx is sighted monocularly. Operators should have visual acuity testing and know which eye they use to site the larynx.

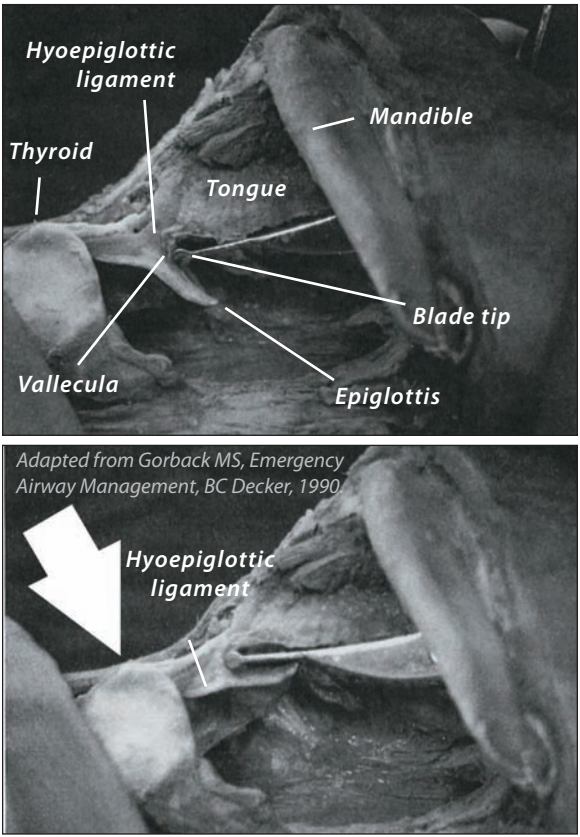
Bimanual Laryngoscopy

Bimanual laryngoscopy. The force on the neck is opposite direction of lift by the laryngoscope.


An assistant then maintains pressure at this location, freeing the laryngoscopist's right hand to place the tracheal tube.

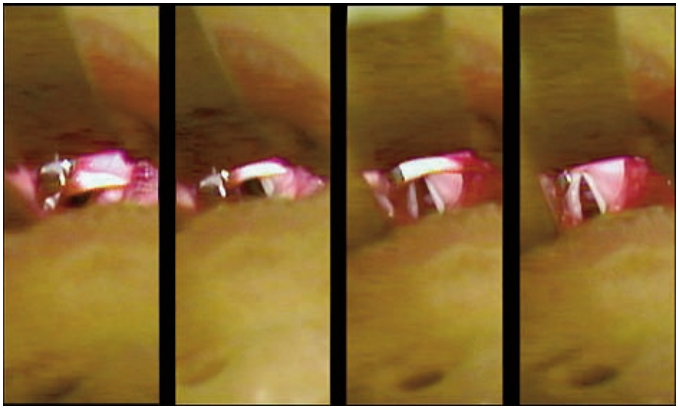
- Bimanual -- By the operator. Not cricoid pressure and not BURP (Backward Upward Rightward Pressure) --these are done by assistants and do not work as well to optimize exposure.

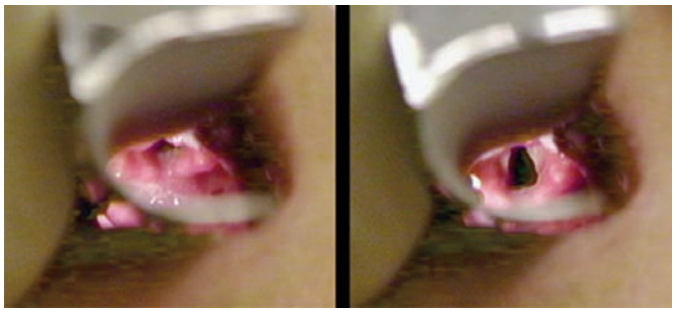
Bimanual Laryngoscopy - Mechanics



- Laryngeal exposure with a curved blade--whether by direct or video--is about subtle mechanical force applied at the base of the epiglottis. The blade tip must be properly placed in the vallecula; bimanual "locks" the tip into the proper position, lifting epiglottis. It also lowers the larynx into the line of sight.

Bimanual Laryngoscopy & Laryngeal View

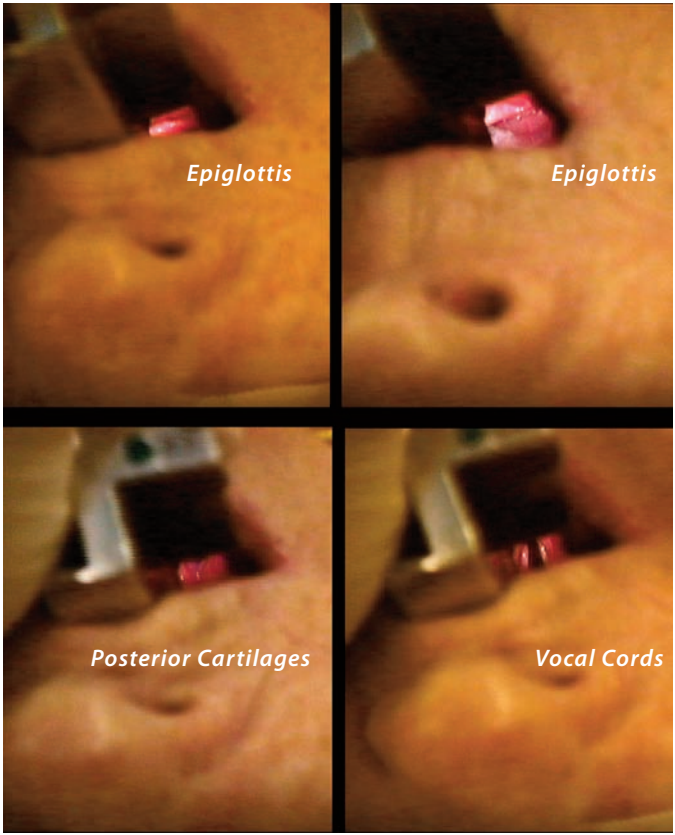




- In curved baldes (example above) bimanual laryngoscopy improves how the blade tip fits into vallecula, improving indirect epiglottis elevation. The larynx os also lowered into the line of sight.

- In straight blades (below) the epiglottis has been picked up directly by the tip of the blade. Improvement in laryngeal view is from pushing the larynx downward into line of sight.

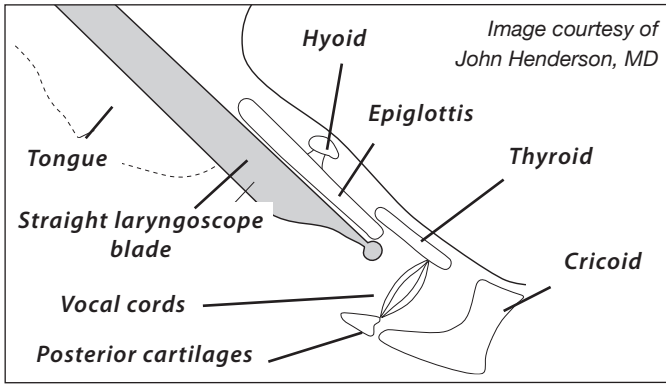
Bimanual Laryngoscopy & Laryngeal View



- Bimanual laryngoscopy in an elderly woman with no teeth, using a Macintosh blade.

- Laryngeal exposure improves dramatically and a view of only the posterior cartilages is transformed to a view of the cords.

Straight Blade - Lifting Epigottis Directly



- Most modern laryngoscopy--with direct or video devices--is done using curved blades and involve indirect epiglottis elevation. Straight blades can be very useful in situations when indirect elevation of the epiglottis is problematic or impossible. This occurs commonly with peri-laryngeal pathology, such as epiglottitis, epiglottic cysts, tumors, polyps, angioedema, etc.

- Straight blades are also very useful when the thyromental distance, i.e., the displacement space between chin and thyroid cartilage, is very short. This is the rule in infants and small children, and with an omega shaped, relatively long epiglottis indirect control can be difficult.

- Straight blades are introduced as curved blades, but then should be moved to the right corner of the mouth (as this is the pivot area where the dental arch arcs backward). The blade tip enters the laryngeal inlet, lifting the epiglottis directly. Tube delivery should be from the extreme right corner of the mouth.

Incrementalized Direct Laryngoscopy:

- Epiglottoscopy > Laryngoscopy > Tube Delivery

- T -5 minutes: Pre-oxygenation and NG decompression if needed. Verify functioning IV lines.

- T - 1 minute: RSI --Give induction agent and muscle relaxant, one after the other. RN times and call out 60 seconds after pushing meds (i.e., when it is safe to attempt blade insertion).

- T -1 to Time zero: Increase NC to 15 lpm if not done already (NO DESAT). Gently ventilate with PEEP awaiting muscle relaxation, upright or in ear-to-sternal notch position. Use low rate, volume, and pressure (6-8 ml/kg, 8-12 breaths/min) unless severe acidosis with compensatory respiratory alkalosis.

- Time zero: 2 finger grip and light force--for epiglottoscopy and tongue control. Follow curve of blade down tongue midline. Suction posterior pharynx as necessary--expose progressive landmarks: uvula, epiglottis, and larynx. After localizing larynx, control tongue (blade moves right, tongue left). Change to high force grip. Use bimanual laryngoscopy and/or head elevation to augment laryngeal exposure.

- Tube delivery is from the right side of the mouth, with straight-to-cuff narrow long-axis stylet shape. Visualize tip passing over notch. If mechanical problem of insertion (catching on tracheal rings) turn tube right. Use bougie as needed.

- Verify tube placement with end-tidal CO2, oximetry, CXR.

Pre-Intubation Checklist

***SOAP–ME**: A mnemonic to prepare for intubation.*

Suction. Yankauer suction catheter on the right side of thepatient's head, within reach of the operator's right hand during laryngoscopy. When properly connected, the suction is audible and palpable when the tip of the catheter is touched against the hand.

Oxygen. Bag valve mask resuscitator with PEEP valve connected to an oxygen source at tuened all the way up (>15 lpm). The flow of oxygen should be audible and high enough to fill the reservoir bag or tubing. Squeeze bag against hand to verify positive pressure. Nasal cannula on patient.

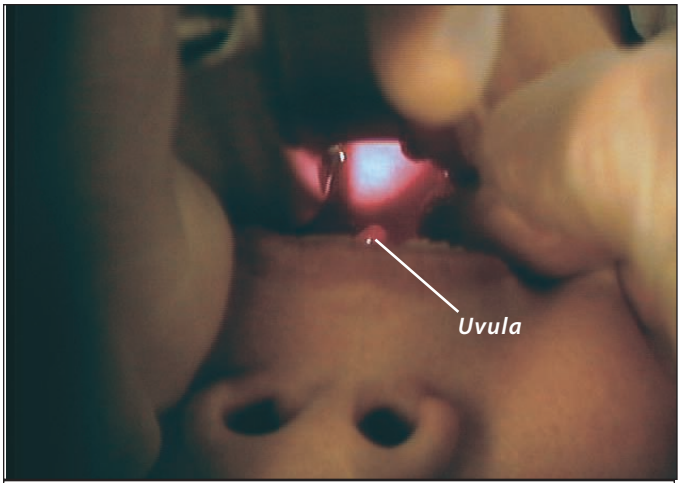
Airways. Oral and nasal airways and rescue ventilation devices. The cuff of the tracheal tube should be checked and fully deflated. The tracheal tube should be styletted with a straight-to-cuff shape for direct, or hyperangulated at approximately 70 degrees for Glidescope, Storz D-Blade, or McGarth X-blade. Tip of stylet should stop at or before distal edge of cuff, leaving the last 2-3 cm of tube flexible.

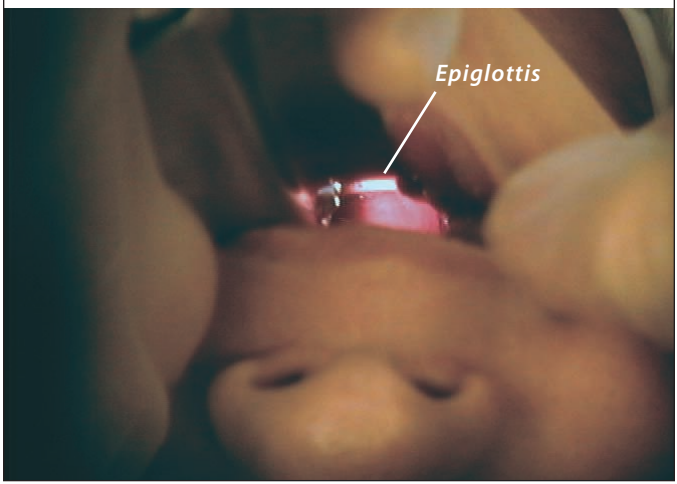
Positioning and Pre-Oxygenation. 4 minutes of pre-oxygenation with nasal cannula and mask if possible. Position patient as upright as possible. NC at 4-6 in wide awake, not hypoxic patient; 15 lpm in critically hypoxic, severely dyspneic patient.

Monitoring equipment and Medications. In patients without a pulse, laryngoscopy will occur immediately as monitoring is also being established. With RSI, the patient should have continuous pulse oximetry and cardiac monitoring, and pre-and post-procedure blood pressure monitoring. All medications should be drawn and labeled. The laryngoscopist should clearly communicate with the eam regarding the sequence and timing of medications.

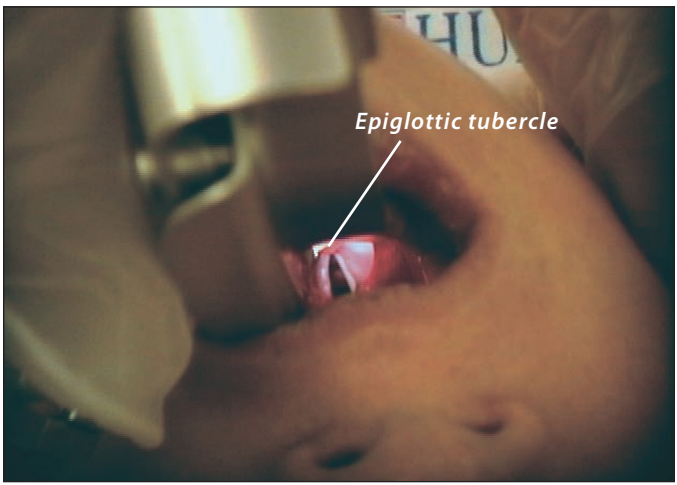
End-tidal CO_2 device. All patients require end-tidal CO_2 monitoring, preferably by capnography or capnometry.

Direct Laryngoscopy - Sequence 1
Macintosh Blade & Bimanual

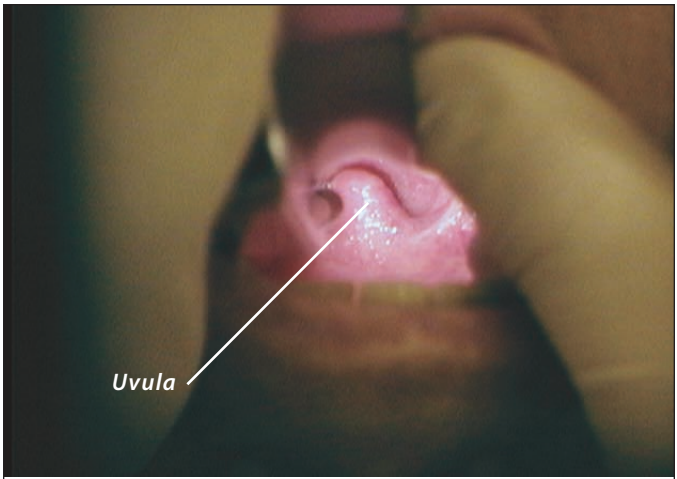


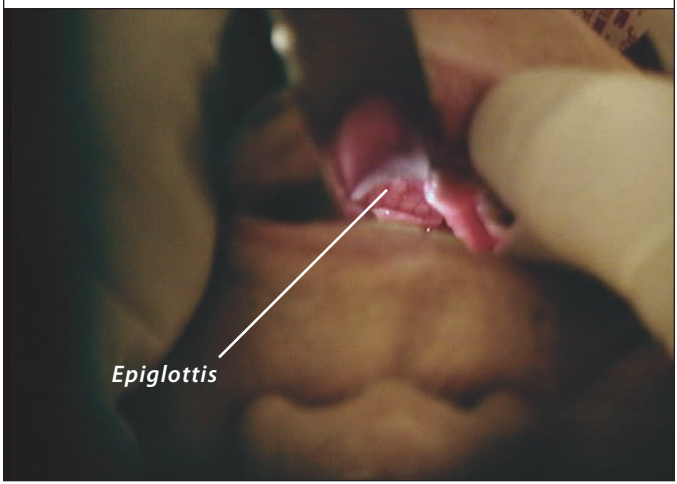


Direct Laryngoscopy - Sequence 1
Macintosh Blade & Bimanual

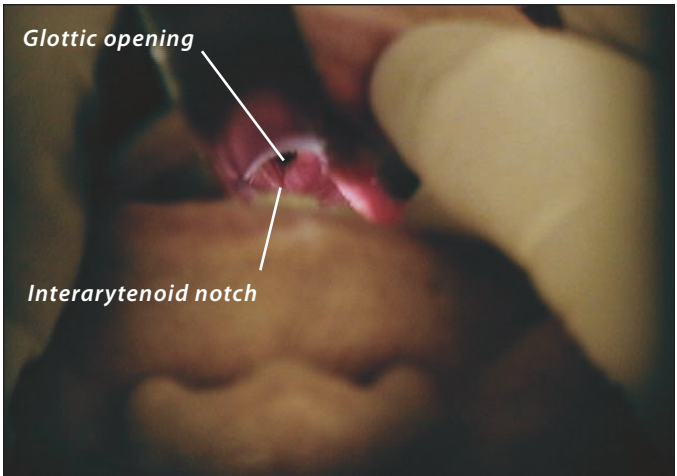


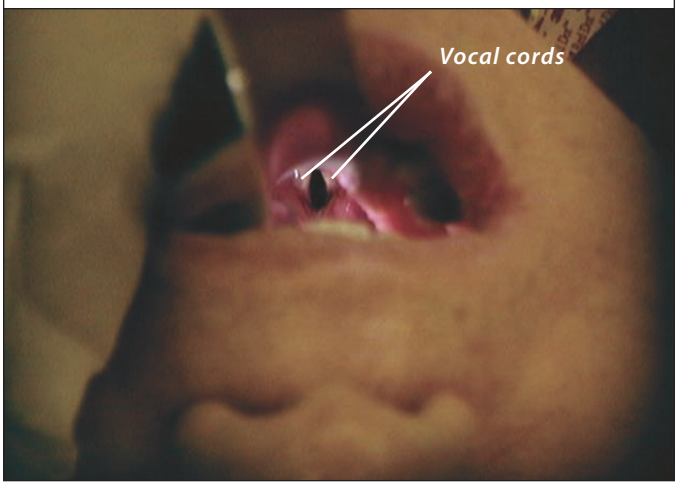
Direct Laryngoscopy - Sequence 2
Macintosh Blade



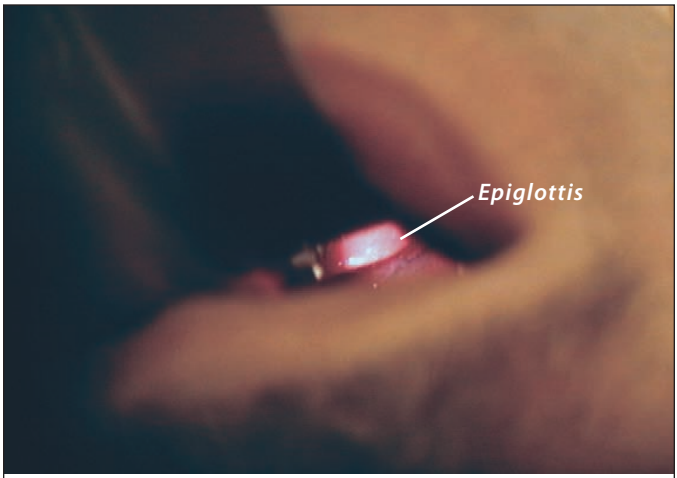


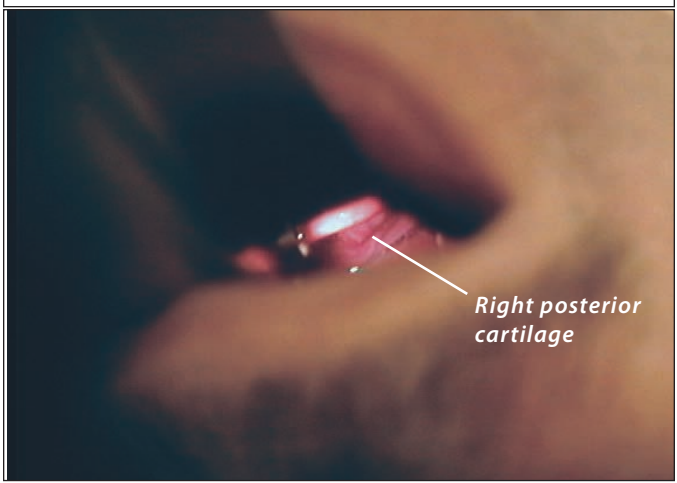
Direct Laryngoscopy - Sequence 2
Macintosh Blade



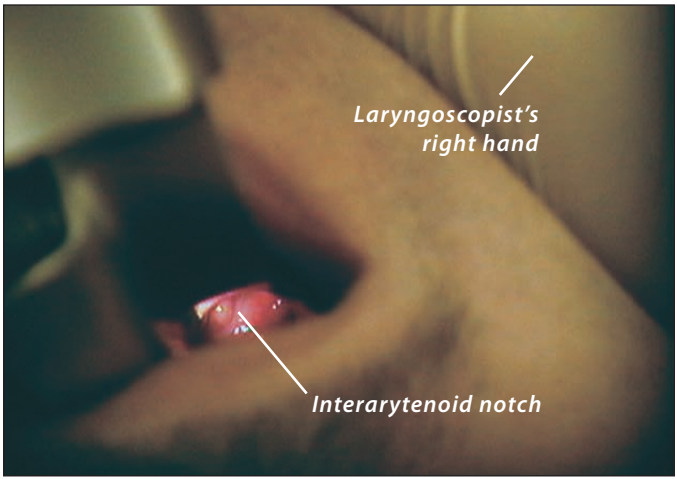


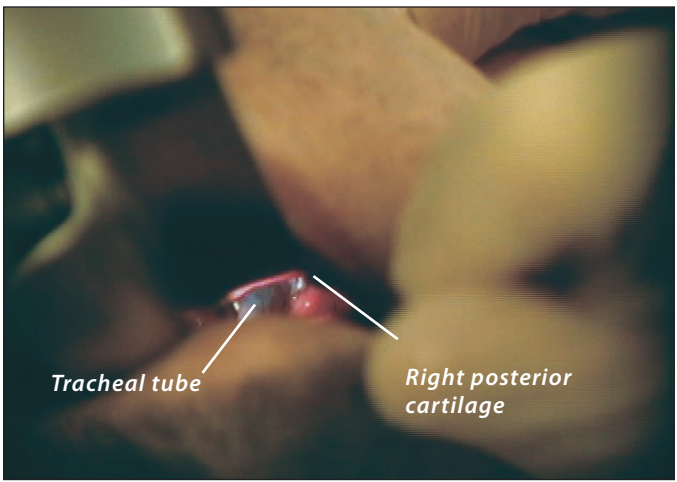
Direct Laryngoscopy - Sequence 3
Macintosh Blade, Posterior Structures Only



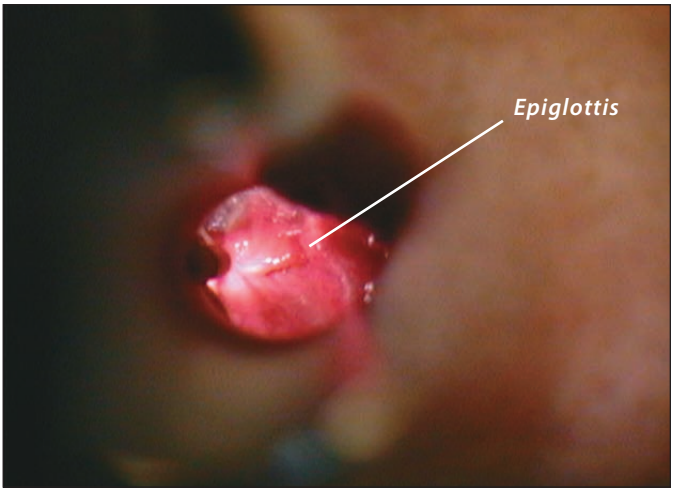


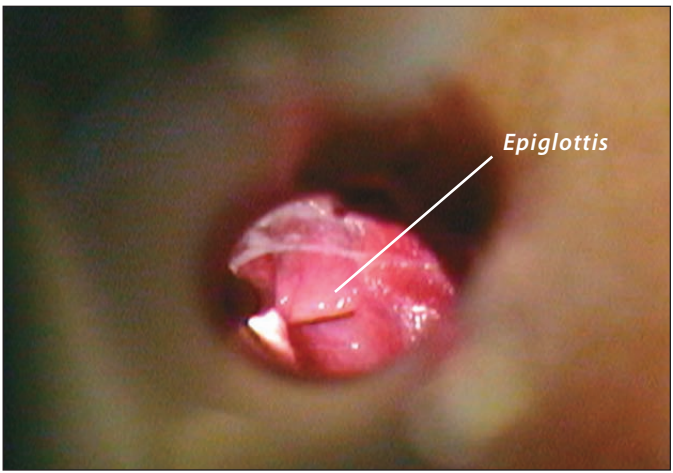
Direct Laryngoscopy - Sequence 3
Macintosh Blade, Posterior Structures Only



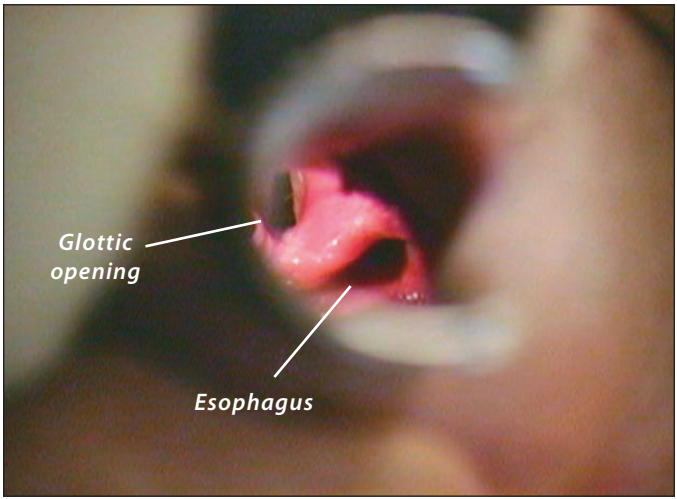


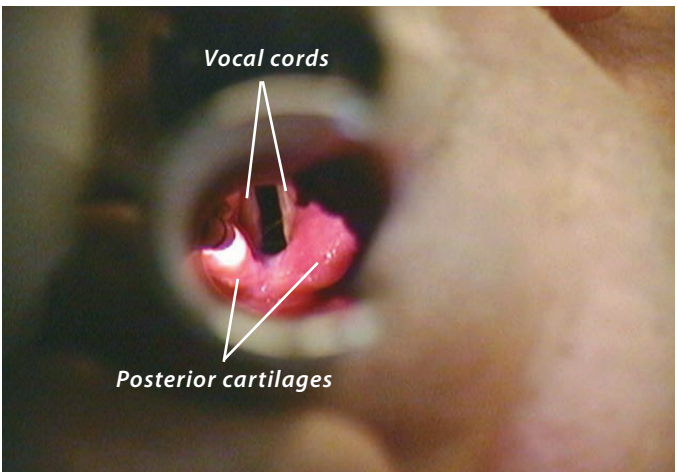
Direct Laryngoscopy - Sequence 4
Straight Blade (Wisconsin)





Direct Laryngoscopy - Sequence 4
Straight Blade (Wisconsin)





Problem Solving Direct Laryngoscopy

- The most common "problem" with direct laryngoscopy is laryngeal exposure. Tube delivery is generally straightforward.

- "Difficult" laryngoscopy is commonly overcome by a more experienced operator using the same instrument, i.e., the problem is often the operator, not the device.

- Expert laryngoscoists move slowly down the tongue and identify the epigottis on insertion; novices frequently over run the epiglottis and fail to identify any structures.

- Problem: No landmarks seen:
a) Using a 2 finger grip on laryngoscope roll midline down the tongue until epiglottis is identified (uvula points to epiglottis).
b) Dab posterior pharyngeal wall with Yankauer suction tip to discriminate edge of epiglottis as necessary.

- Problem: Laryngeal exposure, i.e. epiglottis only view:
a) With light force, adjust tip of blade to fit fully into the vallecula
b) Apply bimanual laryngoscopy
c) Increase head elevation (avoid atlanto-occipital extension)
d) If epiglottis still a problem, use tip of curved blade (or straight blade) to lift the epiglottis directly.

Problem: Tube delivery (straight-to cuff 35 degree bend tube)
a) If resistance felt on insertion, rotate left-bevel tube/stylet to right, or use bougie.
b) Advance tube from below line of sight, pivot in the right corner of the mouth, and watch tip pass over interarytenoid notch.

Incrementalized Video Laryngoscopy

- Same overall strategy as direct laryngoscopy: epiglttoscopy, laryngoscopy, and tube delivery.

- Same pre-oxygenation, positioning, drug timing, nasal cannula (NO DESAT) etc. as direct laryngoscopy.

- Time zero: 2 finger grip--epiglottoscopy, and tongue control--all with low force. Follow curve of blade down tongue midline. Uvula points to epiglottis. Suction pharynx as necessary. Same as direct laryngoscopy.

- Hyperangulated blades stay midline; conventionally shaped Mac video laryngoscopes control tongue left (blade moves right).

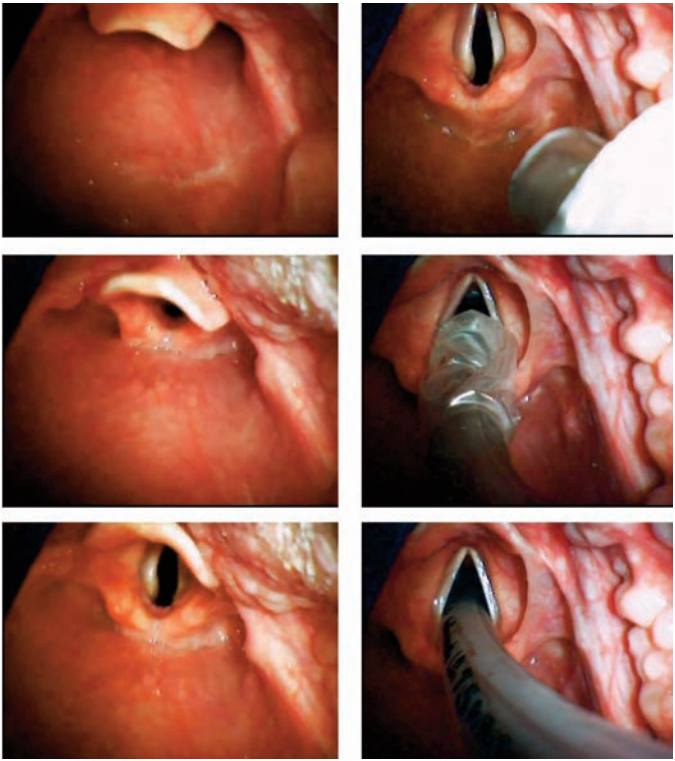
- Improve laryngeal exposure with bimanual laryngoscopy or head elevation.

- Tube delivery with video devices follows the blade down to glottis. Directly observe tube insertion in mouth, move down the blade, and then watch on video as tube tip enters glottis.

- Hyperangulated stylets are used for tube delivery with hyperangulated blades, but cannot be inserted into trachea. See page 88 for more information. Conventional shaped video laryngoscope blades use a conventionally shaped stylet/tube (i.e. straight to cuff). For channeled video devices, no stylet is used. Adjusting device position as necessary to modify the direction of tube movement from the channel.

- Verify tube placement with end-tidal CO2, oximetry, CXR.

Video Laryngoscopy: Sequence 1



- Ideal demonstration of hyperangulated Glidescope technique. Slow insertion, epiglottoscopy, target is kept in upper half of screen, and laryngeal inlet is aligned with axis of blade.

- Tube insertion is visible from the bottom half of screen, and the tube is clearly seen entering the larynx.

- Images courtesy of Riuchard Cooper, MD.

Video Laryngoscopy: Sequence 2

- Video laryngoscopy using Glidescope Titanium Macintosh blade in super obese man who happens to have a long tubular epiglottis. Initially it was very tough to identify any structures, but epiglottis edge was recognize, and then the blade tip positioned further down the tongue, into the vallecula using bimanual laryngoscopy.

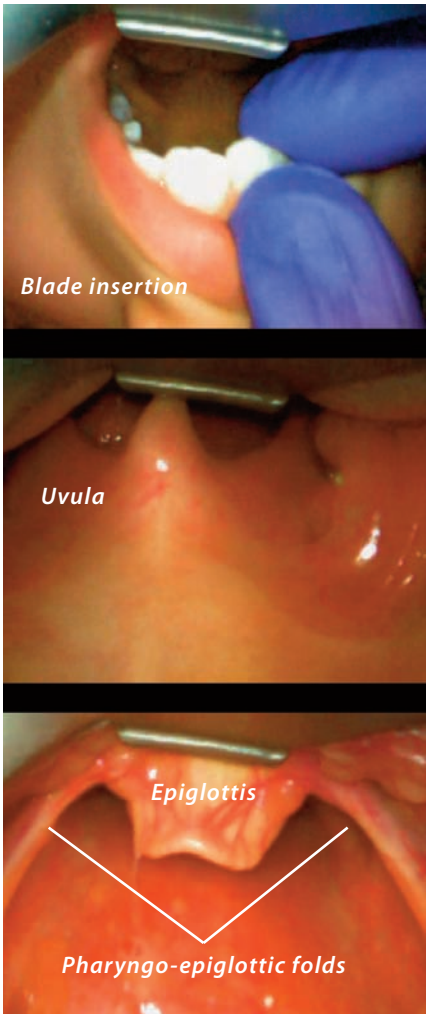
- The cords and glottis are shadowed by the long tubular epiglottis, but the posterior cartilages are seen in top right image.

- Tube delivery is done carefully, as the cuff of the tracheal tube transiently blocks the line of imaging (bottom left).

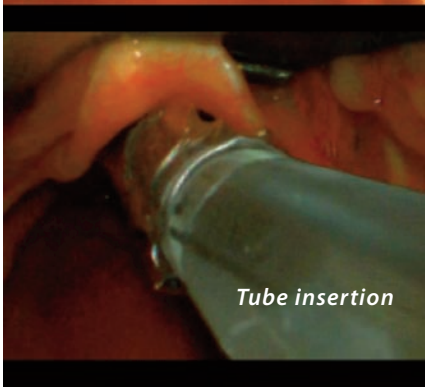
Video Laryngoscopy Sequence 3

- Intubation in a 5 year old with a Storz C-Mac video laryngoscope.

Images courtesy of Paul Baker, MD.



Video Laryngoscopy Sequence 3

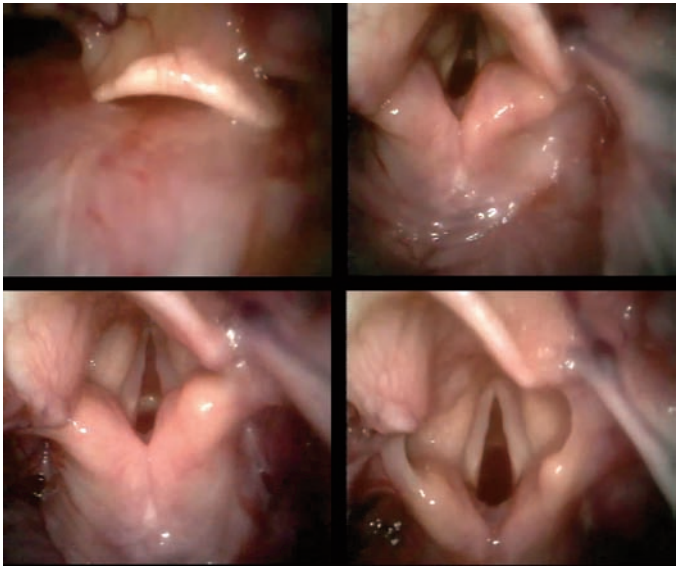


- After a terrific view of the larynx is obtained, notice that tube insertion causes a transient blockage of the target as the tube moves between the viewing element on the blade and the larynx.

- It is important to always verify the tube position after insertion, as shown in the bottom image. The tube is clearly passing above the posterior cartilages and notch.

Tube delivery should always be slow and smooth, avoiding esophageal placement, and also so it is accomplished on first attempt.

Video Laryngoscopy Sequence 4



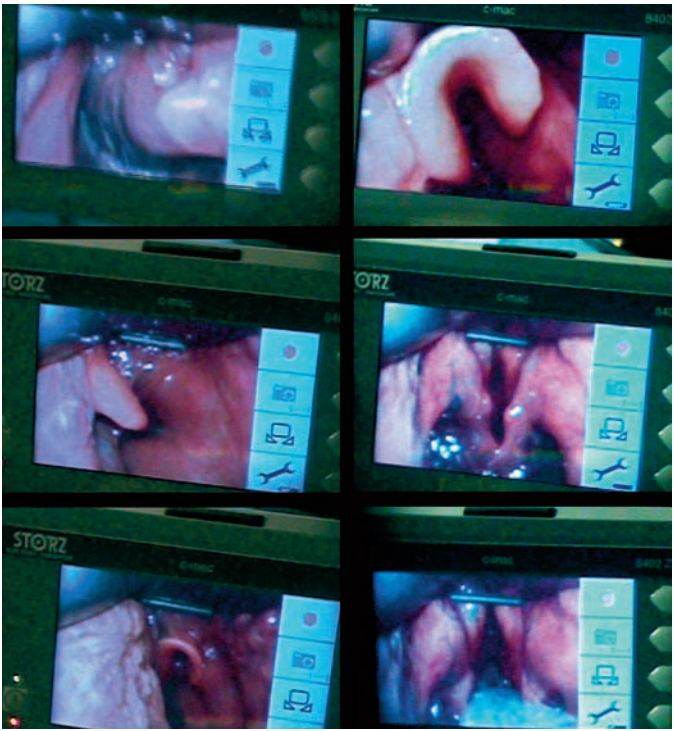
- Sequential Glidescope images in which the hyperangulated blade is over-inserted and off axis relative to the larynx.

- The blade has been advanced too far (bottom left), the viewing element is too close to the target, filling screen, and steepening the angle of approach (see p. 82). The epiglottis is pointing leftward because the blade has been positioned right of midline.

- Tube insertion is being attempted in the bottom right image, but cannot be seen. This can easily lead to injuries of the palate and tonsils.

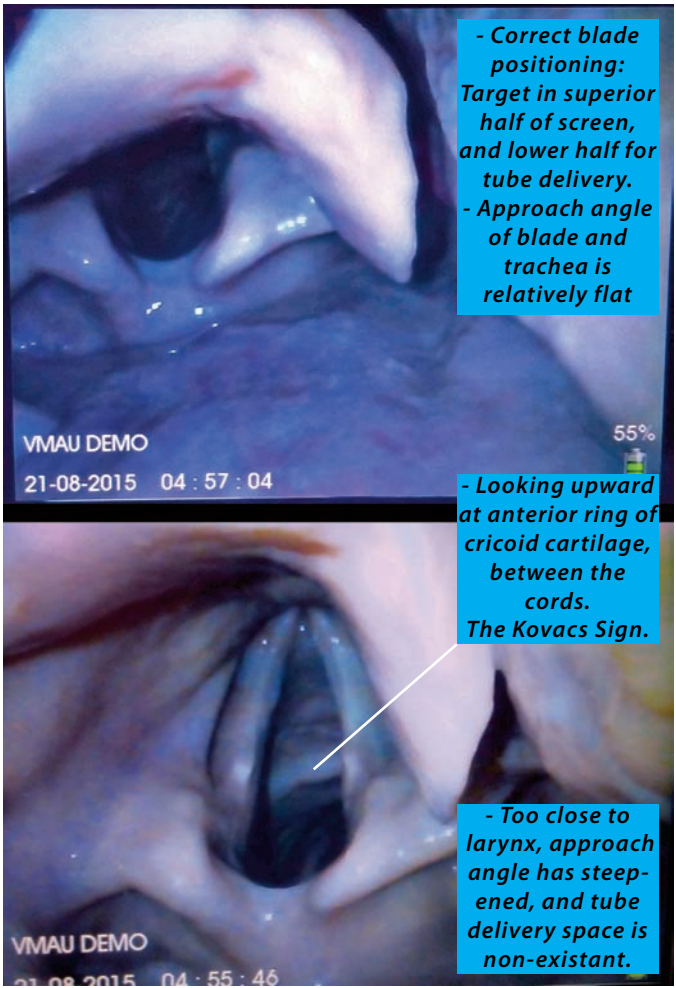
- Images courtesy of Marvin Wayne, MD.

Video Laryngoscopy Sequence 5

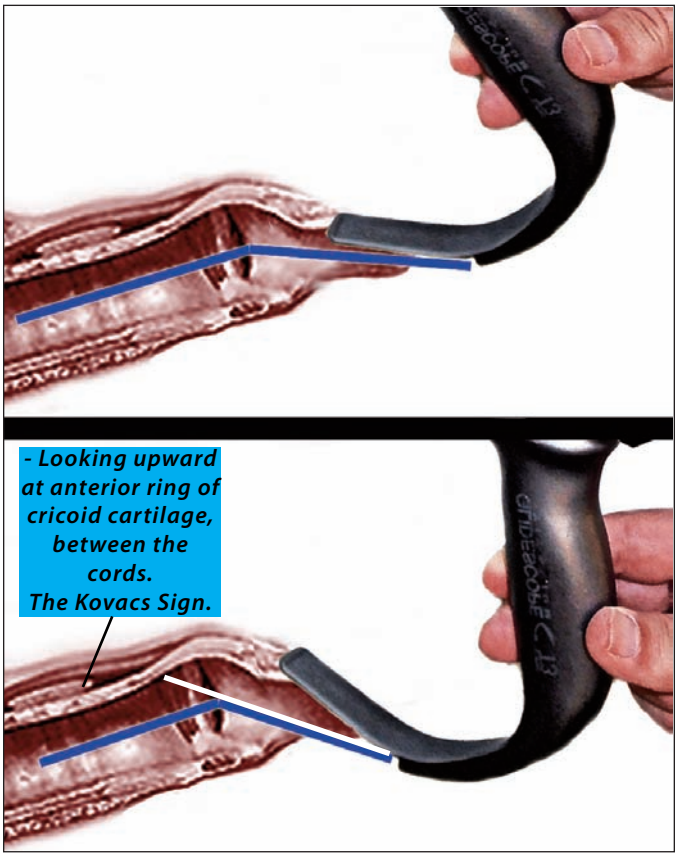


- C-Mac vidoelaryngoscopy in a super-obese man with difficult anatomy. Initial image of generous soft tissue including the tongue, soft palate and pharyngo-epiglottic folds. The epiglottis is identified in second image on left, but the large tongue made it dificult to find, and it is way off midline. The next challenge was controlling the epiglottis to achieve exposure and tube delivery. After various attempts at indirect elevation, laryngoscopy and intubation was only possible by lifting tubular epiglottis directly.

Hyperangulated Video Laryngoscopy & the Angle of Approach


- Correct blade positioning: Target in superior half of screen, and lower half for tube delivery.
- Approach angle of blade and trachea is relatively flat
VMAU DEMO
21-08-2015 04 : 57 : 04
55%
- Looking upward at anterior ring of cricoid cartilage, between the cords.
The Kovacs Sign.
- Too close to larynx, approach angle has steep-ened, and tube delivery space is non-existant.
VMAU DEMO

Hyperangulated Video Laryngoscopy & The Angle of Approach



- Schematic representation of images on opposite page. Angle of approach is steeper in bottom image and viewing element is closer to target. Tube insertion has to overcome a more acute angle.

Problem Solving Video Laryngoscopy

- No landmarks: Back up, and incrementally advance down the center of the tongue, going very slowly, progressively visualizing uvula and palatal arch, dabbing posterior pharyngeal wall with Yankauer. Uvula points to the epiglottis.

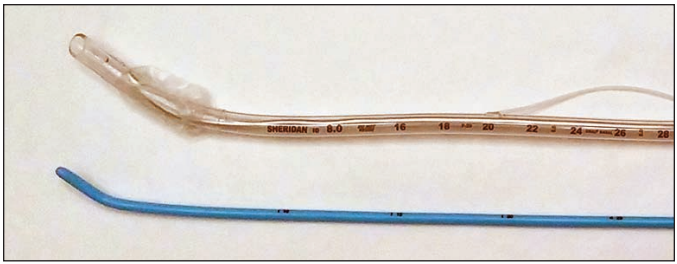
- No landmarks with hyperangulated blade: Use a smaller blade. The viewing element of a hyperangulated Glidescope 4 blade comes off farther from the tip of the blade than the hyperangulated Glidescope 3. For most adults the Glidescope size 3 is the best choice. Smaller blades also create a less acute angle of approach and often create easier tube delivery (see pp. 81-82).

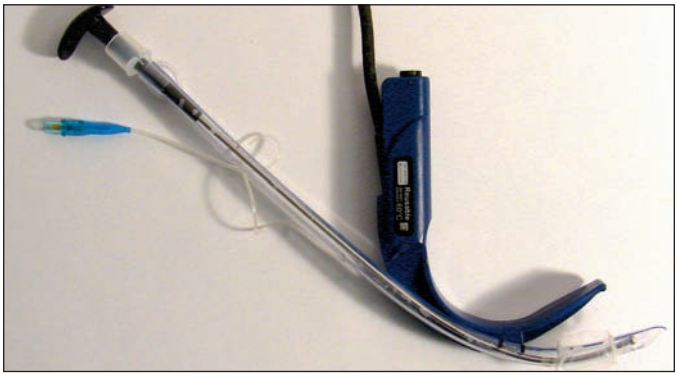
- Difficulty getting tube to target: Use the blade as the conduit to move to larynx. DIrectly visualize insertion into the mouth, gently advance down the blade until it comes into view on the monitor.

- Poor visualization of tube insertion into the larynx: Video laryngoscopes usually provide much better visualization of the tube insertion compared to direct laryngoscopy, however as the tube moves down the blade, the tube and cuff can obscure the video imaging element. Often it is hard to see the leading edge of a left bevel tube. Manipulate the tube below the video imaging element so you can see the tip coming over the interarytenoid notch.

- Difficult tube insertion into trachea: Do not attempt to insert hyperangulated stylet and tube into trachea without addressing corrugation and inclination issues (pp.87-89).

Tube Delivery - Direct & Hyperangulated

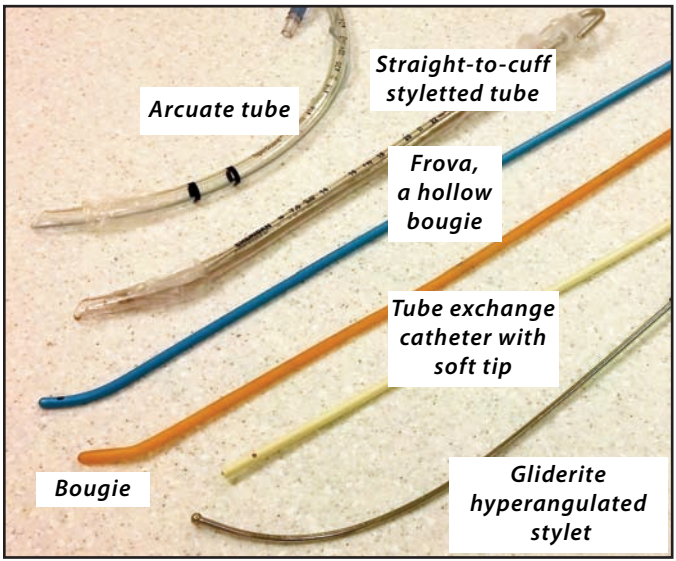




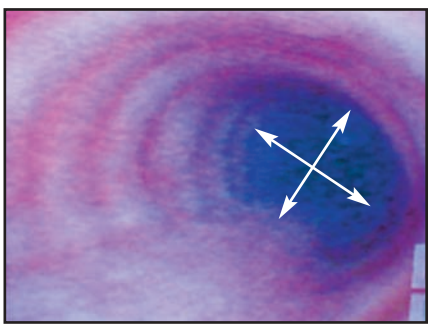
- With conventional shaped laryngoscope blades (direct or video) there is a direct line of sight to the target. insertion is easiest with a straight instrument that has a long narrow axis. This can be achieved with a straight-to-cuff styletted tube or a bougie (shown in top image).

- With a hyperangulated blade, a stylet is used to follow the blade around the tongue to reach the target, but this "tongue turner" cannot be passed into trachea. It exceeds the dimensions of the trachea, and is not aligned with tracheal direction.

Tube Delivery Devices Respecting the Dimensions of the Trachea

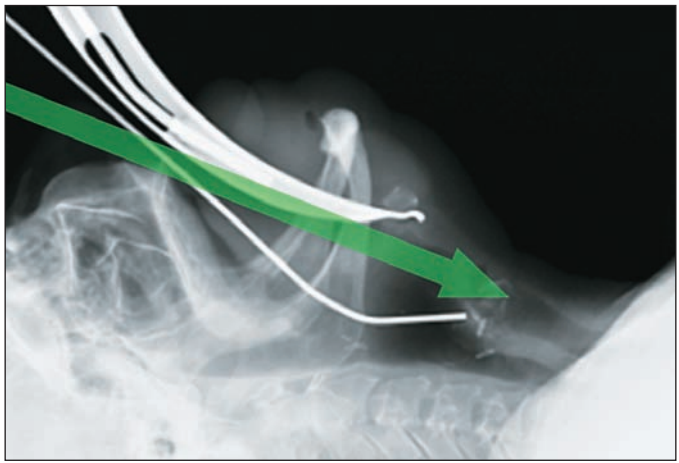


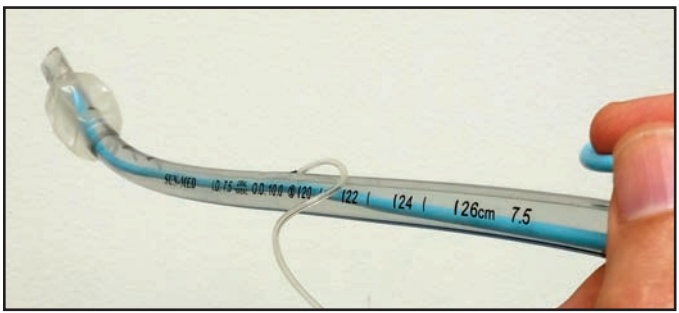
- *PVC tracheal tubes have an arcuate shape making them difficult to insert.*



- *Straight-to-cuff styletted tubes (bend < 35 degrees), and bougies respect the anatomic dimensions of the trachea (15-20 mm in males, 14-16 mm in females).*

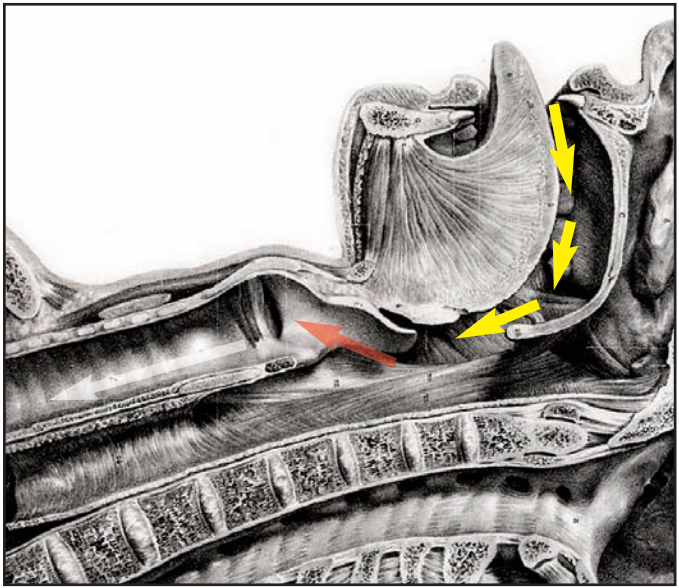
Tube Delivery - Coming from Below Line of Sight





- Tracheal tubes must be inserted carefully to avoid moving into the line of sight and blocking the target. Radiograph shows straight-to-cuff styletted tube (below) inserted in the mouth, having been moved toward larynx, now pivoting over posterior structures, and coming from below line of sight to the target.

Tube Insertion: Corrugation & inclination

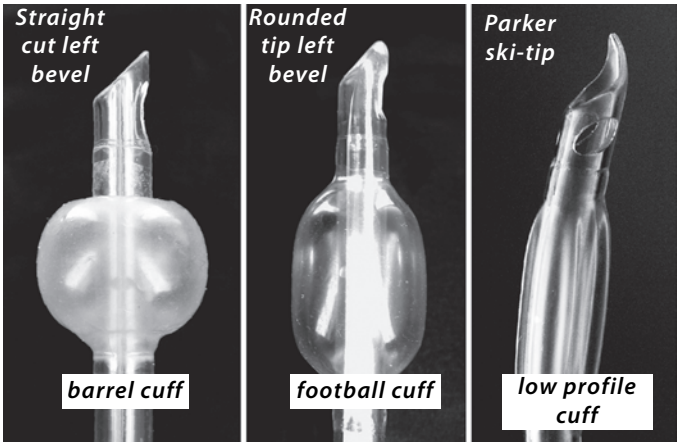


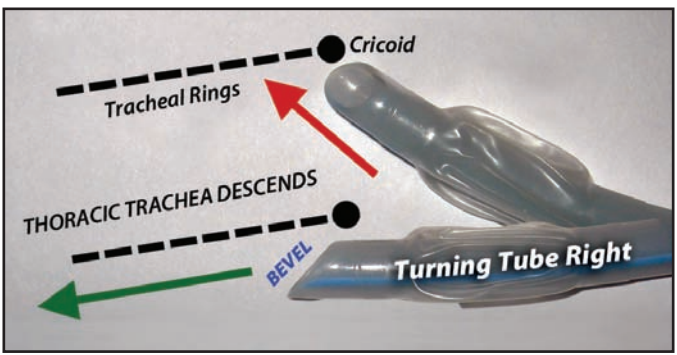
- The trachea descends into the thorax, following the thoracic spine. The inclination of the trachea (white) is different than the axis of the laryngeal inlet (pale red) and the curvature around the tongue (yellow).

- The anterior tracheal rings create what is essentially a small corrugated tube.

- Any rigid device that is used to get a tube around the tongue cannot be inserted fully into the trachea, due to the trachea's small dimesion, corrugation, and inclination.

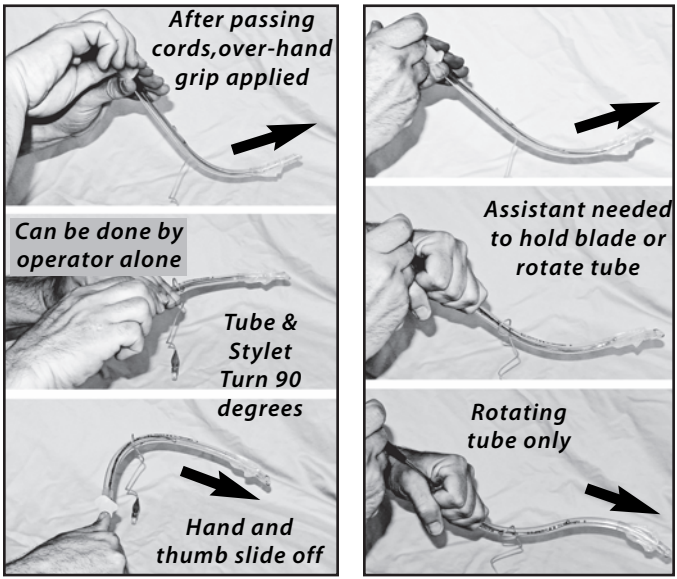
Tracheal Tube Tips and Insertion





- Standard tubes have a left-facing bevel, either with a straight cut, or a slight rounded tip. The Parker tube has a symmetric ski-tip shaped tip. Turning tracheal tubes to the right when they contact the tracheal rings causes the bevel to face upwards, and the inclination to turn down, facilitating insertion.

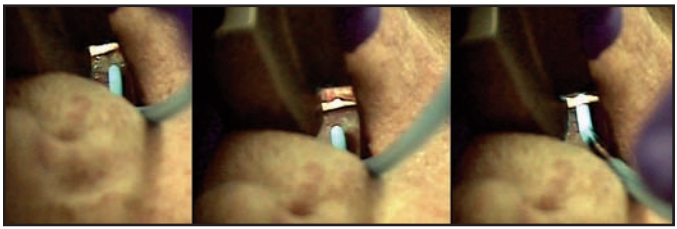
Tube Insertion with Hyperangulated Stylet

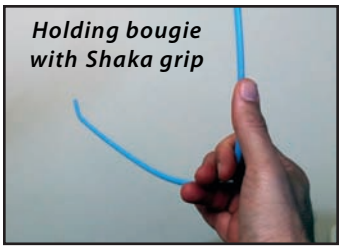

After passing cords,over-hand grip applied
Can be done by operator alone
Tube & Stylet Turn 90 degrees
Hand and thumb slide off
Assistant needed to hold blade or rotate tube
Rotating tube only

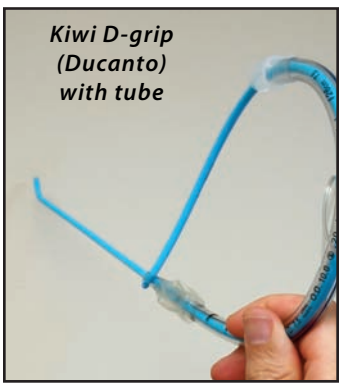
- The standard approach to dealing with a hyperangulated stylet is to withdraw the stylet after the tube tip is through the cords, and then try pushing the tube down into the trachea. But the tube comes off the stylet pointing upward, following the upward arc of the stylet, not the downward inclination of the trachea (top). This can cause mechanical impaction.

- On the left series of images, the stylet and tube are both turned rightward 90 degrees. The tube can then be advanced off the stylet with one hand (can be donw without asistance). On the right series, the tube alone is rotated rightward 90 degrees (assistant needed). Either approach solves the problems of corrugation (bevel up) and inclination (tube down).

Tube introducer, a.k.a. “Bougie”





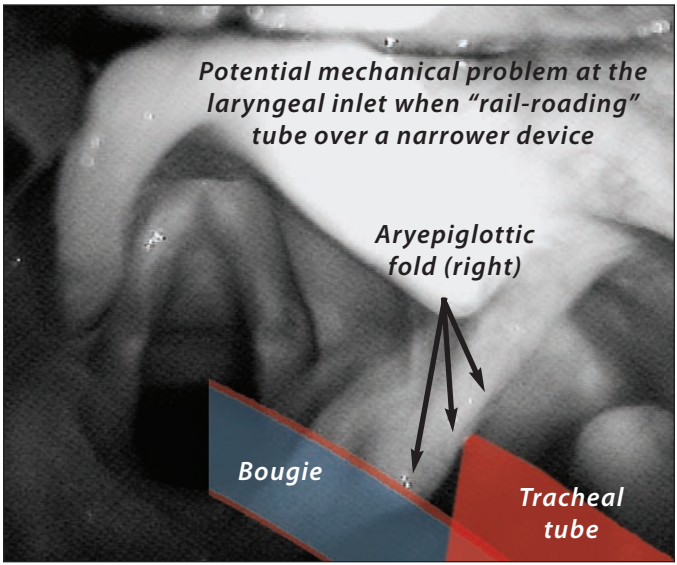


- The “bougie” is a tube introducer with a narrow long-axis and an upturned distal tip. It has an OD of 5 mm, smaller than any tracheal tube.

- The upturned tip facilitates visualization and it bounces off the trachea rings, providing a tactile confirmation of tracheal placement.

- It is useful to know the direction of the upturned tip on placement, especially in poor views. Special grips labelled above allow this (unlike a standard pencil grip on device).

Sliding Tube over the Bougie into Trachea


Potential mechanical problem at the laryngeal inlet when "rail-roading" tube over a narrower device
Aryepiglottic fold (right)
Bougie
Tracheal tube

- Tubes can catch at the inlet, due to the gap between the outer diameter of the bougie (5mm) or a thin scope, and the ID of a tracheal tube. CCW rotation closes the gap.

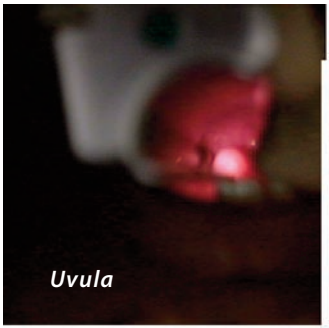
Pediatric Intubation Overview

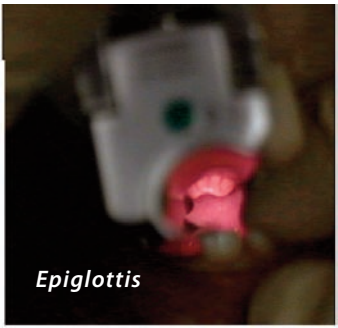
- Pediatric intubation is technically easier than adult intubation. Poor laryngeal views are 10x less common in children than in adults. The procedure is more stressful to clinicains, making an incrementalized, step-wise approach even more important.

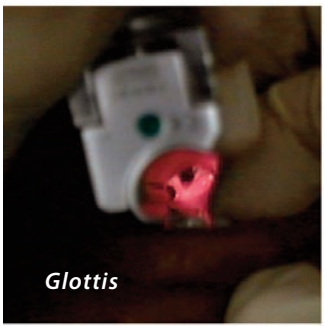
- Epiglottoscopy is critical--in infants the uvula and epiglottis touch. The epiglottis is relatively long and can be difficult to control. infants and children have a short thyromental distance, meaning a small displacement space for the tongue. All of these variables favor the use of straight blades in small children. Straight blades are recommended for infants and most children below the age of 4. Curved blades do better for suctioning in high volume fluid situations.

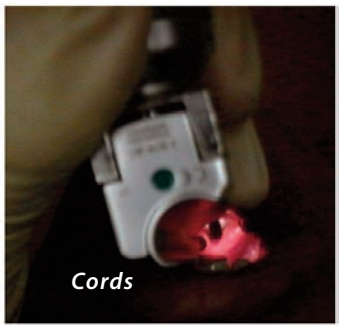
- Surgical airways in small children require tracheotomy; below the age of 8 cricothyrotomy is not feasible. Infants have more tracheal rings (~10) above the sternal notch vs. adults (4-6).

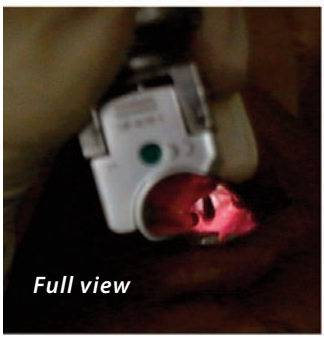
Pediatric Laryngoscopy Sequence 1

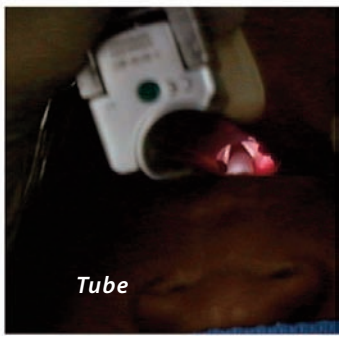




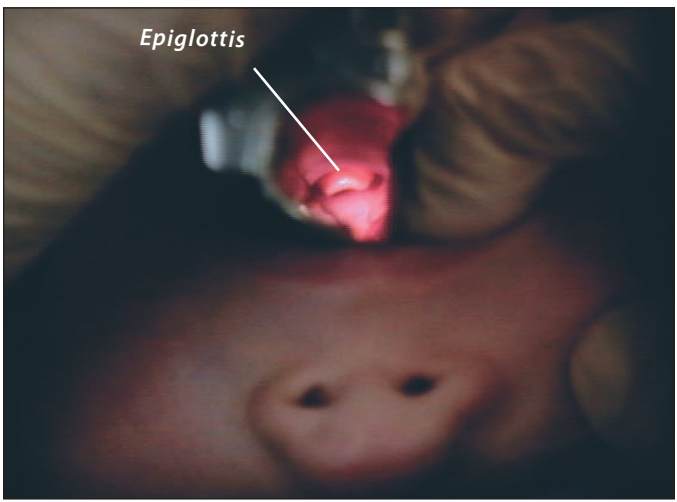


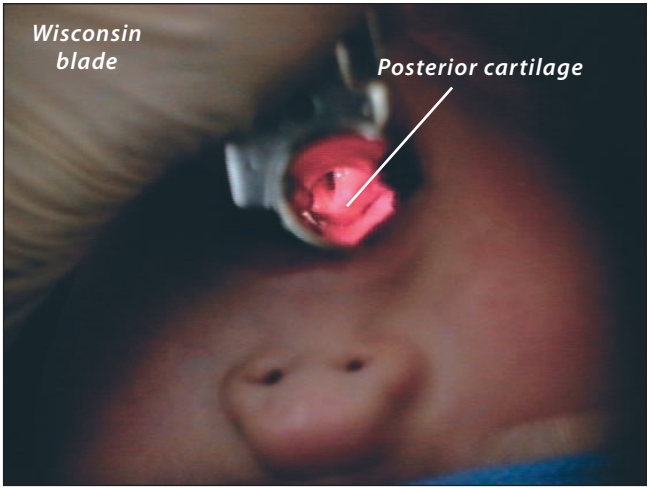


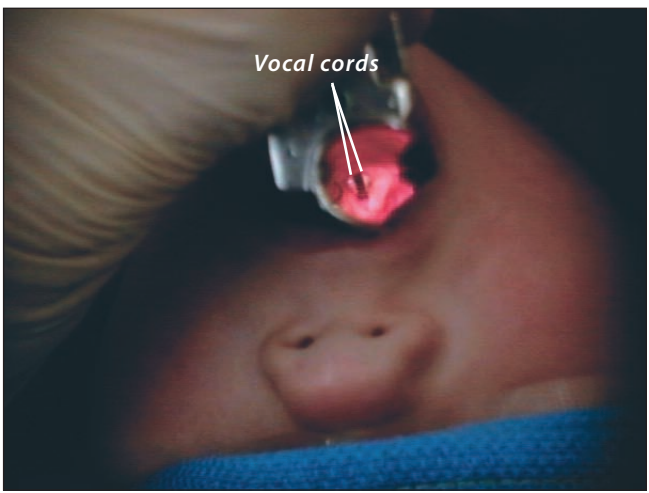




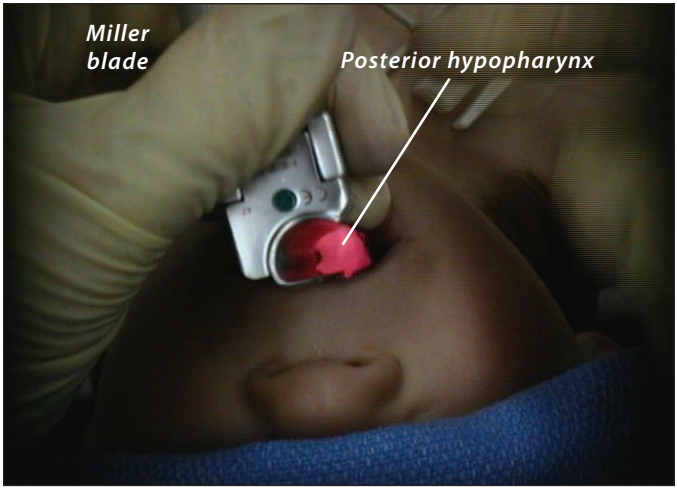
Pediatric Laryngoscopy Sequence 2

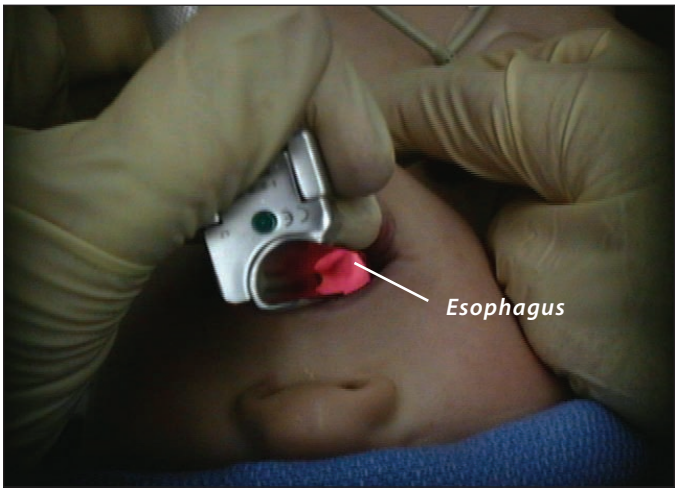



Wisconsin blade
Posterior cartilage

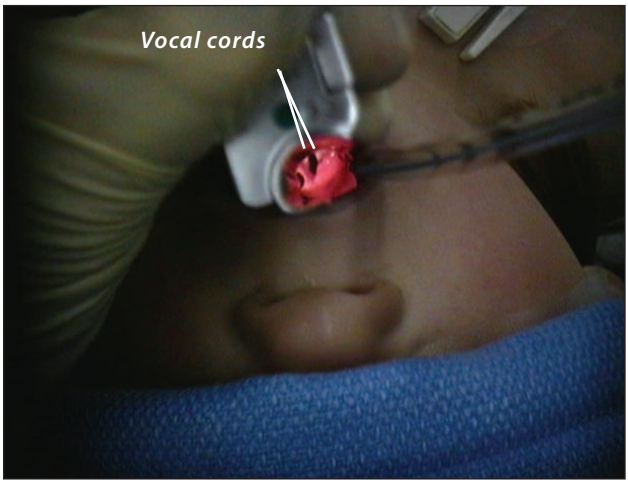

Vocal cords

Pediatric Laryngoscopy Sequence 3

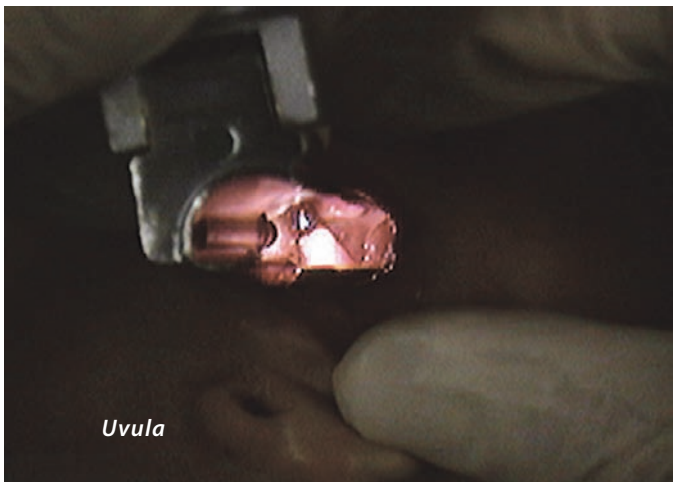




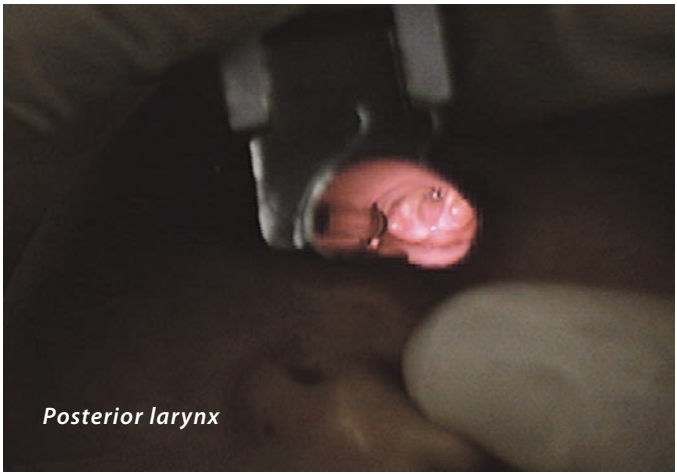
Pediatric Laryngoscopy Sequence 3



Pediatric Laryngoscopy Sequence 4



Pediatric Laryngoscopy Sequence 4



Posterior larynx

Full view

Decision Making - Use of Muscle Relaxants

- Muscle relaxation (RSI) creates optimal conditions for laryngoscopy oral intubation, insertion of supraglottic airways, and mask ventilation. It also eliminates the risk of active vomting or gagging, a signifcant risk in emergency airways.

- Safety with RSI depends on a redundancy of safety, i.e., a redundancy of means to intubate, and oxygenate. Oxygenation methods include passive oxygenation, face mask, and supraglottic airways. Video laryngoscopy has significantly increased the margin of safety in intubation. Likewise, supraglottic airways and apneic oxygenation have significantly increased the margin of safety in oxygenation. Tolerance of apnea, and the hemodynamic impact of drugs and intubation must also be considered.

- In most emergency situatiions, the benefits of muscle relaxants outweigh the small risks of the cannot intubate/cannot oxygenate situation. Intubation without muscle relaxants has its own risks, such as suboptimal conditions, increased likelihood of repeat and prolonged attempts, and vomiting. Additonally, without an absent gag, supraglottic airways cannot be inserted.

- RSI is generally avoided when rescue oxygenation and ventilation will not likely work. In such situations if intubation fails, a surgical airway is required. Time to ventilation with a surgical airway averages 100 seconds. Occasionally muscle relaxants are used in high risk situations with concurrent preprarations for a surgical airway, i.e. a double set-up. After drug administration, one attempt is made at intubation; a surgical airway is initaited immediately if there is any delay.

Non-RSI Oral intubation

- "Awake" intubation refers to approaches in which patients keep breathing. This can mean different things: 1) topicalization only; 2) topicalization plus some adjunctive sedative agent; 3) topicalization and a large dose of a sedative--which may cause apnea and create significant or even full relaxation in some patients.

- The challenge of "awake" oral intubation is predicting patients' response to the stimulus of laryngoscopy, their risk of gagging and vomiting, and their reponse to sedative agents. Certain clinical situations may allow intubation with minimal pharmacologic adjuncts (decreased patient responsiveness, muscular fatigue): hypercarbia, encephalopathy, overdose, sepsis, profound shock, neuromuscular disease, etc. In neonates and infants it is usually easy to physically overcome resistance to laryngoscopy.

- When response to laryngoscopy is expected to be minimal, a laryngoscope can be inserted to gauge patient response--and then perform intubation if feasible, or deciding to then switch to RSI after assessing the likelihood of intubation success.

- Ketamine has unique properties relative to other induction agents and is often chosen for "awake", non-RSI approaches (through mouth, nose, or neck). It is a unique dissociative agent that generally does not impair respiration but creates "cooperation in a vial." Ketamine, combined with topicalization of the airway, gentle insertion of a video laryngoscope, and a bougie is often effective for "awake" oral intubation.

- In any "awake"approach, be ready to use RSI medications, manage regurgiation, and adapt to patient's response.

Non-RSI Nasal intubation

- The nasal route of intubation is chosen in situations of obvious pathology about the mouth and base of tongue.

- Nasal intubation can be done with sedatives and muscle relaxation (using a mask system and bronchoscope swivel adaptor to provide continuous ventilation during endoscopy), but it most often chosen because of an expected challenging airway, and a desire to keep the patient upright, beathing spontaneously.

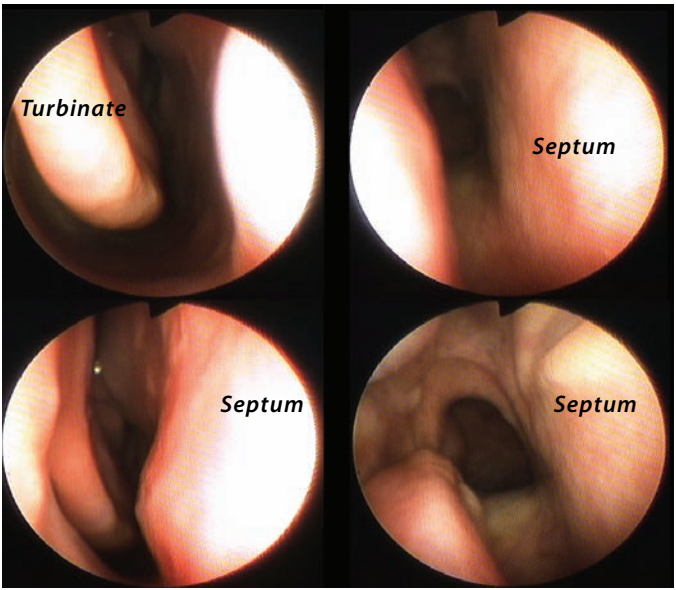
- Sedation and pharmacologic adjuncts required are less than is necessary for going through the mouth, but vasoconstriction of the nose, and topicalization of the nasopharyx and larynx is critical. Ketmaine can be used is small aliquots to aid in minimizing movement and patient resistance.

- Because a nasal approach is often chosen in situations of obvious anatomic problems with the mouth, operators must anticipate the need for a surgical airway if nasal intubation fails, as many of these patients cannot be effectively oxygenated using mask ventilation or supraglottic airways. Mark the neck, have the surgical airway equipment at bedside.

- Blind nasal intubation is feasible, but endoscopic guidance is very helpful and often part of the reason a nasal intubation is being chosen, i.e. in order to inspect the larynx and airway--in burns, angioedema, pathology about the tongue, etc.

- 2 basic approaches: 1) tube first--tracheal tube placed in nare to depth 12-14 cm, then followed by scope; 2) tube loaded on scope, scope passed from nose to carina, tube railroaded down.

Nasoendoscopy Landmarks

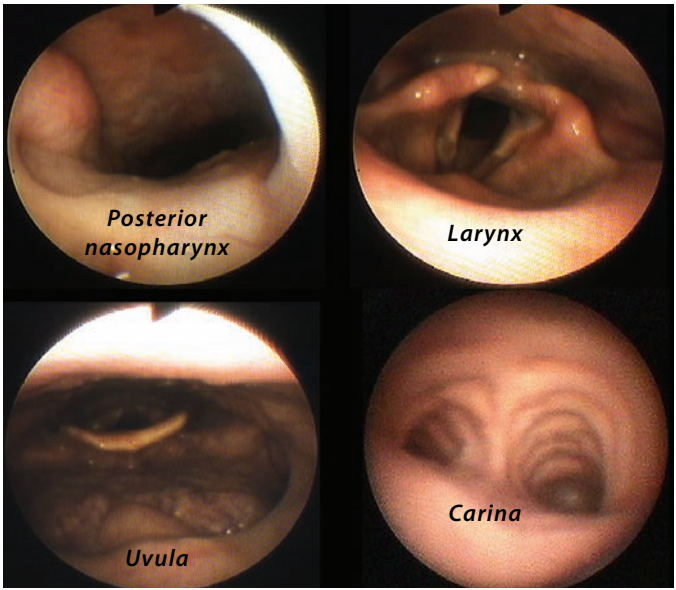


- Nasoendoscopy is a valuable tool for airway assessment and relatively easy to perform. It is especially useful managing and assessing angioedema, burns, vocal cord function, and foreign bodies. Endoscopy is also useful for checking tracheostomies.

- Before nasoendoscopy spray the nare with topical anesthetic and vasoconstrictant. Have nothing behind the patient's head.

The basic "rules" of endoscopy are:
- Know your starting position and proceed slowly
- Maintain a perspective on critical landmarks
- Follow the open channel.

Nasoendoscopy Landmarks



- Visually insert scope in open nare, be gentle in the first one inch, navigating around inferior turbinate and any septal spur. At the back of the nasopharynx, have the patient breathe through their nose, and lean slightly forward.

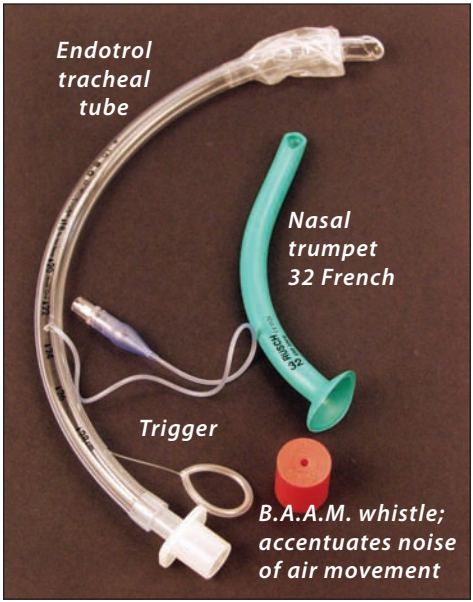
- The scope is passed back through the nasopharynx, then downward over the posterior nasopharynx to the hypopharynx, where the epigottis and larynx should come into view. Try to avoid touching the posterior pharyngeal wall and epiglottis.

- Bottom right image shows view of carina (seen with 60 cm bronchoscope, not 30 cm rhinolaryngoscope).

Nasal Intubation Specialized Equipment

- Trigger tubes allow flexion of the distal tip of the tube by pulling on ring. Endotrol has a left bevel-- CCW rotation needed as tube slid off scope--not needed with Parker tip.

- Trumpet should always preceed tube.



- Nasal intubation is ideally performed with an endoscopic technique, as many indications for it's use are better assessed by an endoscopic view of the airway. Do not blindly intubate if there is laryngotracheal pathology. In addition to standard endoscopes, there now is a single-use intubating endoscope, the AMBU A-Scope (page 40).

- 2 general approaches: 1) scope first (tube loaded at base of scope, scope then navigates nare > trachea, tube slid from nare to trachea); or 2) tube first (tube placed blindly to depth of 12 to 14 cm at nare, scope inserted through tube to larynx > trachea--and then tube slid off). Tube first is faster, with less navigation.

Incrementalized Blind Nasal intubation

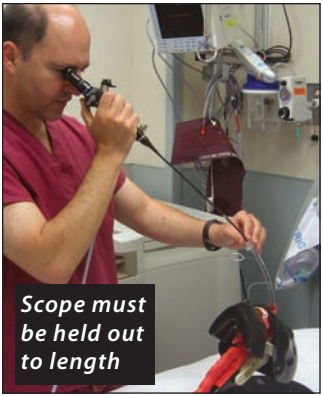
Left: Insertion of the trumpet or tube into the nare is initially straight back, perpendicular to the face, and medial toward the septum. Radiograph shows tube in nasopharynx.

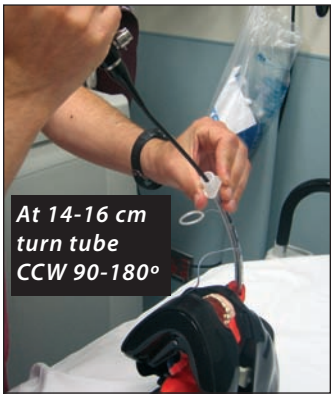
Right: Advancing the tracheal tube toward the larynx, while keeping the base of the tube directed at the contralateral nipple. This keeps the tube midline as it passes toward the larynx.

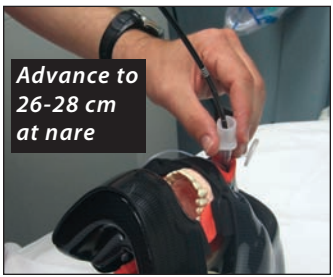
incrementalized Nasal Intubation Technique (S-T-S-T-S-T): Spray, Trumpet, Spray, Tube, Spray, Tube .

1 ***S*** **-** Anesthetic sprays into nare (combination of oxymetazoline and 4% topical lidocaine.
2 ***T*** - Insert 32 French soft nasal trumpet, lubricated with 2% lidocaine jelly, straight back (90º to face plane), directed midline.
3 ***S*** - Spray anesthetic through trumpet twice. Patient will cough as anesthesia hits larynx. Remove trumpet.
4 ***T*** - Insert tracheal tube to approximately 12-14 cm, keeping the proximal end of the tube directed toward the patient's contralateral nipple (this directs the tip of the tube toward the midline – see above). Loud breath sounds should be audible through the tube.
5 ***S*** - Spray anesthetic once more through tracheal tube.
6 ***T*** - Pass tracheal tube through cords on inspiration.
7 - Confirm placement (loss of phonation, breath sounds, end-tidal CO_2) and secure tube (26 cm at nare for women and 28 cm for men).

Nasal Intubation with Endoscopic Guidance



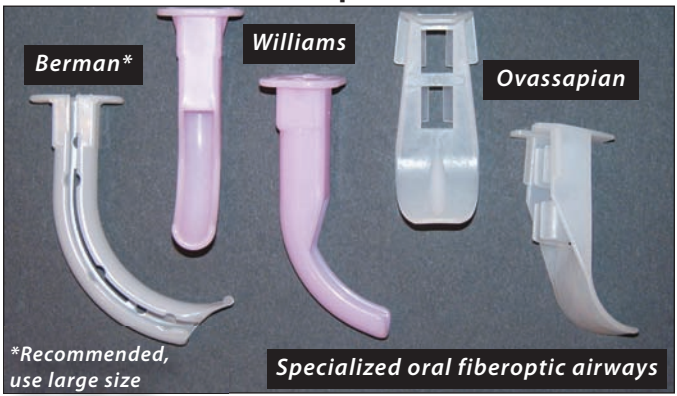


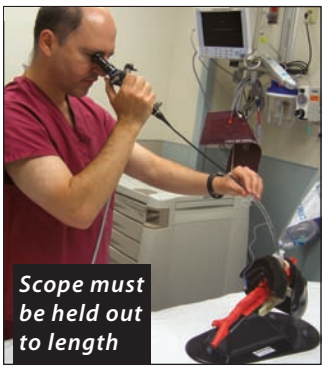


- Sequence of nasotracheal endoscopic intubation, using a tube first approach. Tube has been placed in nare to depth of 12-14 cm (top left), followed by endoscopic navigation into trachea--to level of carina---and then is slid off the scope using a CCW turn (top right) to depth of 26-28 cm (bottom right).

- Navigation endoscopically through nose is avoided with a tube first approach, but care must be taken to avoid bleeding (good topicalization and trumpet use before insertion very important).

Oral Endoscopic Intubation





- Oral endoscopic intubation has a shorter distance but a more acute angle than nasal.

- Scope must navigate curve of tongue and through gap between tongue and posterior pharynx. View on exiting oral airway may be poor. Specialized airways help get around angle of the mouh..

- Intubation via the oral route can be very challenging in supine patients with poor muscular tone. Lift mandible (with jaw thrust or laryngoscope), and lift up on oral airway to open hypopharyngeal space. Once larynx is seen, advance scope to carina, and then pass tube off scope with CCW rotation. LMA devices (pp.39- 41) overcome many technical issues of oral endoscopy.

Save a Life - Cut the Neck !

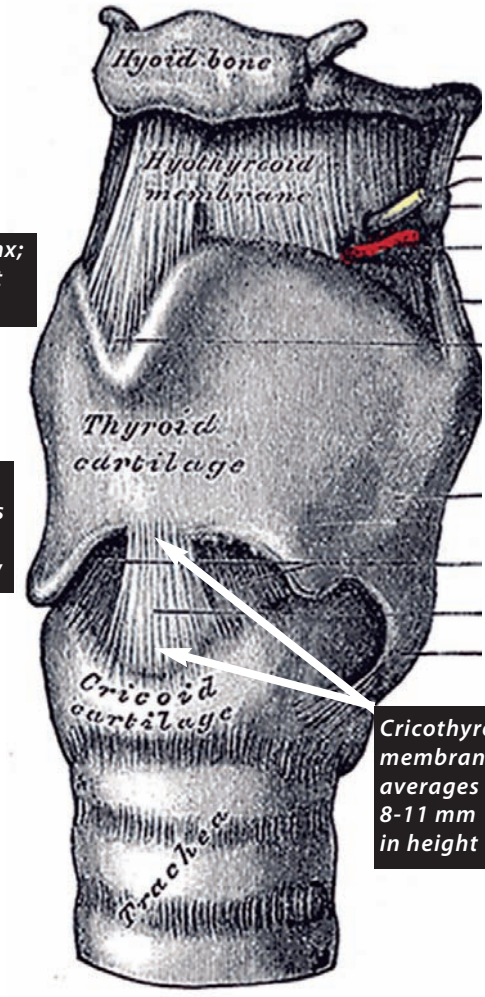
- The surgical airway has been wrongly termed "the failed airway." It should be "the surgically inevitable airway," to clearly label it as something that needed to happen, and was going to happen at some point in the patient's care. When rescue oxygenation via passive oxygenation, face mask, and supraglottic airways will not work, and the patient cannot be intubated from above--we must cut the neck to save a life.

- The first response to hypoxia (and inability to intubate) should not be to cut the neck--but rather to oxygenate--via the incrementalized approach and using SGA's as needed (pp. 28-43). If oxygenation will not work, however, providers must be proactive, and start the surgical airway early--as time to ventilation is approximately 100 seconds.

- Major facial trauma, dynamic pathology about the base of tongue and mouth, and massive fluids (from below) commonly preclude oxygenation and require surgical airways.

- An incrementalized approach to the surgical airway includes:
- *Move to the side of patient that matches your dominant hand*
- *Position patient 45 degrees head up, with neck extension*
- *Continue oxygenation/ventilation efforts during procedure*
- *Find landmarks via "laryngeal handshake"*
- *Stabilize larynx with non-dominant hand*
- *Use sternal stabilization to make a vertical incision*
- *Vertical incision 2.5-3 fingers length, from mid thyroid down*
- *Verify cricothyroid membrane with non-dominant index finger*
- *Cut horizontally through CTM, finger feels cartilaginous cage*
- *Tube inserted, depth/CO2 checked, secure tube, CXR*

Surgical Airway Anatomy

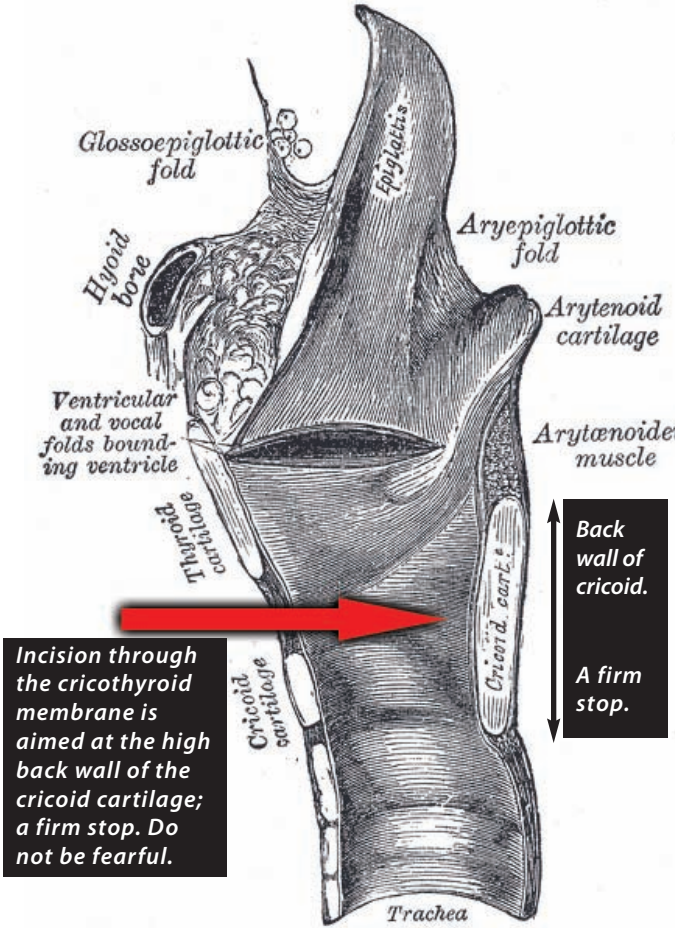


Male larynx; prominent thryoid

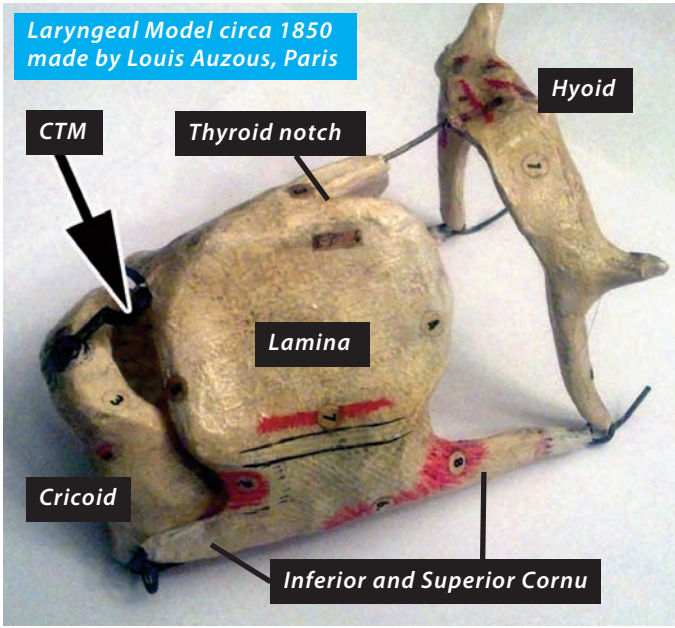
Thyroid overlaps cricoid laterally

Cricothyroid membrane averages 8-11 mm in height

Surgical Airway Anatomy


Glossoepiglottic fold
Epiglottis
Aryepiglottic fold
Hyoid bone
Arytenoid cartilage
Ventricular and vocal folds bounding ventricle
Arytænoide muscle
Thyroid cartilage
Cricoid cartilage
Trachea
Back wall of cricoid.
A firm stop.
Incision through the cricothyroid membrane is aimed at the high back wall of the cricoid cartilage; a firm stop. Do not be fearful.

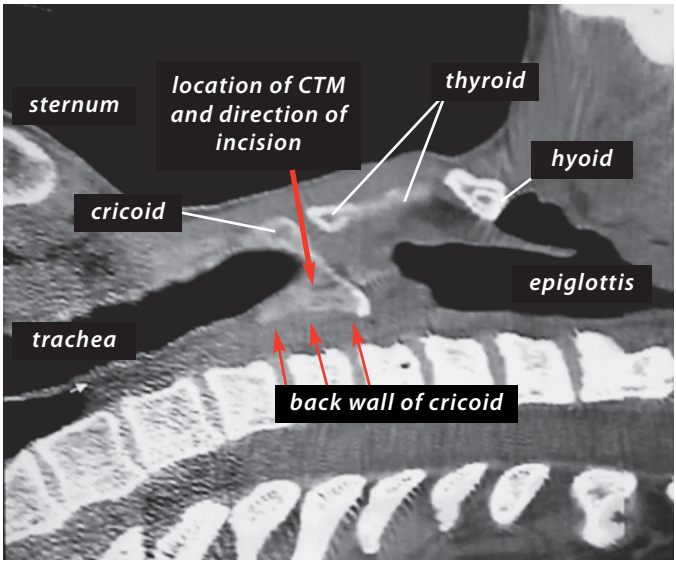
Surgical Airway Anatomy
The Cartilaginous Cage



- The cricothyroid membrane (CTM, arrow) is bounded by a "cartilaginous cage" that is made up of the thyroid cartilage (above the CTM), the anterior cricoid ring (below), the overlap of the thyroid on top of the cricoid (laterally) and the high back wall of the cricoid cartilage (not shown above--see page 111).

- The inferior thyroid cornu overlaps the cricoid cartilage on either side. The superior cornu extend almost to hyoid bone. This is a male thyroid--prominent notch and acute angle of lamina.

Surgical Airway Anatomy
Cartilaginous Cage

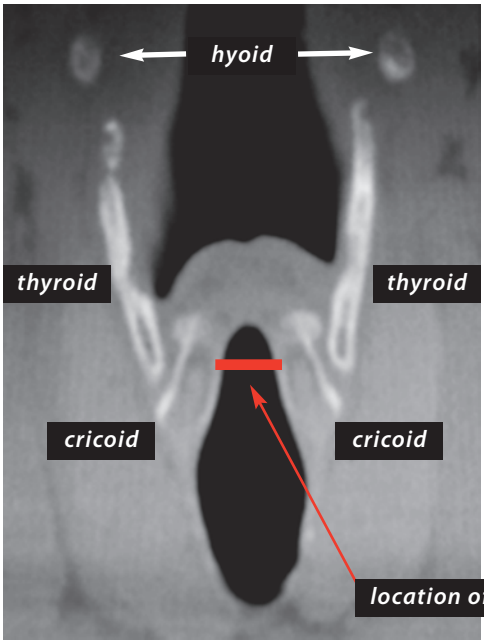


- CT imaging of the neck in a sagittal orientation shows critical landmarks and demonstrates the cartilaginous cage. Emergency providers, who order and review lots of CT neck studies, should use this modality to master laryngeal anatomy.

- Notice the proximty of the back wall of the cricoid to the spine. A tracheal hook is necessary when performing a tracheostomy, but the larynx will not "drop" backward doing a cricothyrotomy. A hook is not necessary to hold the larynx.

- The author advocates scalpel-finger-tube technique for cricothyrotomy (pp116-118).

Laryngeal Handshake
Rock the Rhomboid



- CT imaging of neck in coronal view shows the rhomboid arrangement of larngeal structures, as demonstrated.

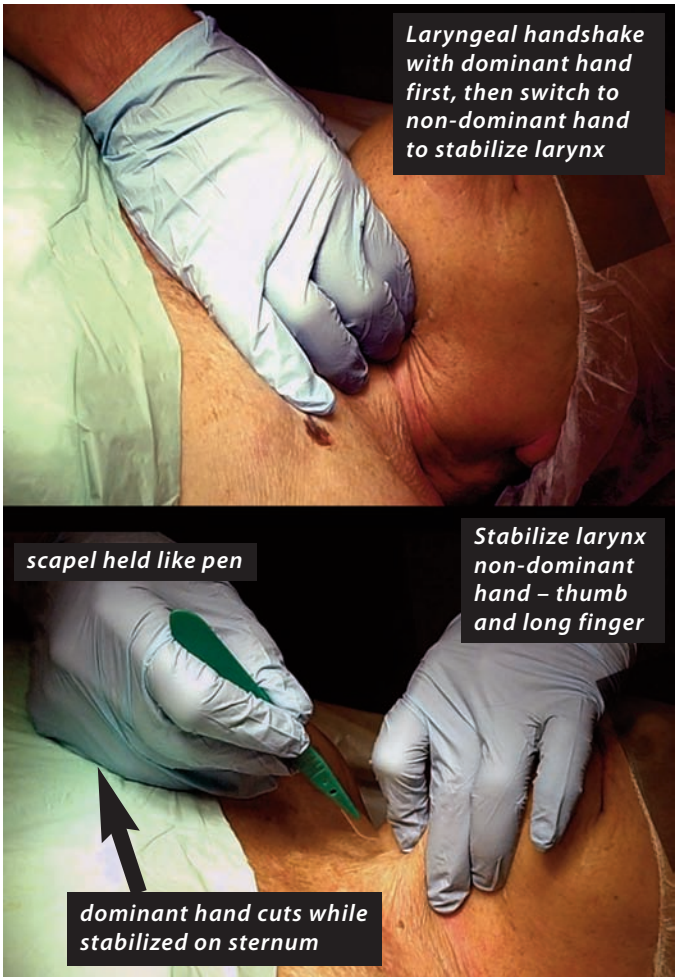
- The superior cornu of the thyroid almost reaches the hyoid.

- The inferior cornu of thyroid overlaps the cricoid cartilage. this is important, as it limits the lateral movement of a scalpel as the CTM membrane is incised, i.e., do not worry about going too latral--there is a firm lateral stop created by overlapping thyroid.

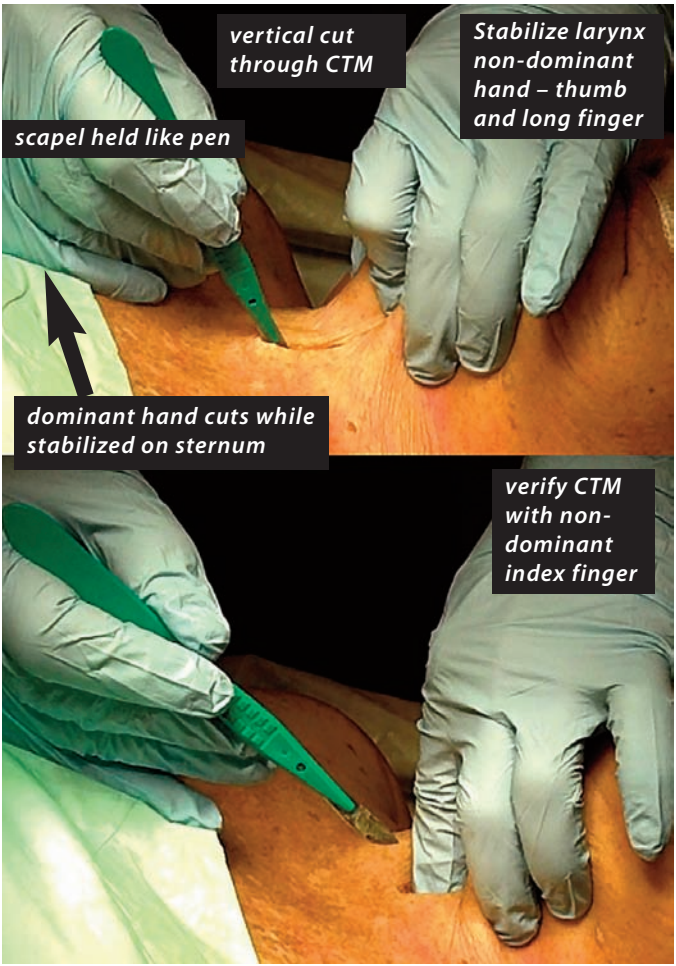
Laryngeal Handshake

- "Laryngeal handshake"–5 fingers to "rock the rhonboid" of the larynx, palpate from top to bottom: hyoid-thryoid-cricoid.

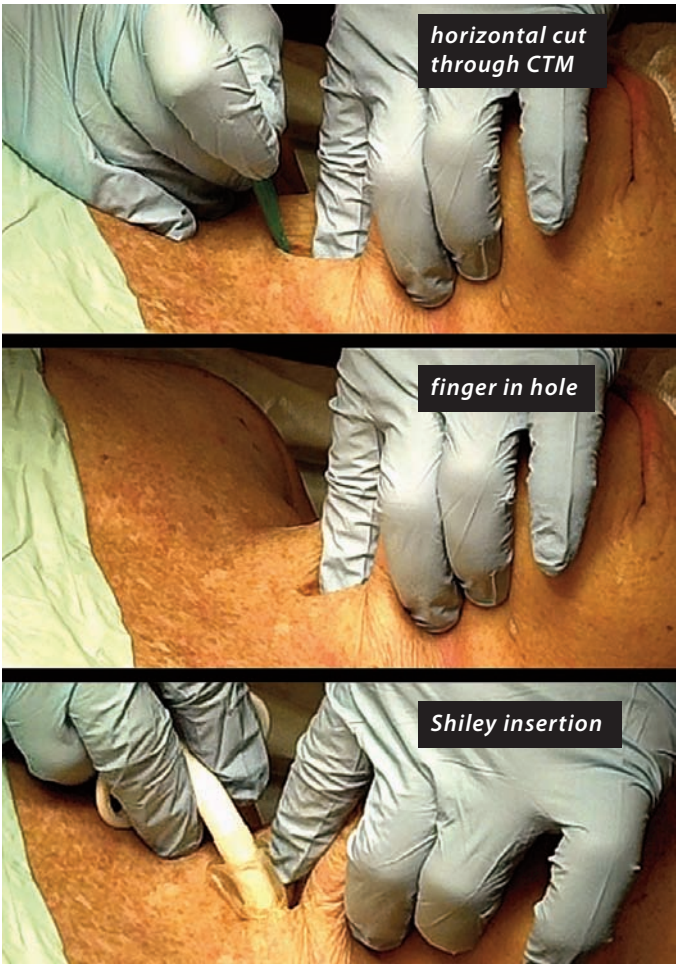
Incrementalized Approach to Cricothyrotomy


Laryngeal handshake with dominant hand first, then switch to non-dominant hand to stabilize larynx
scapel held like pen
Stabilize larynx non-dominant hand – thumb and long finger
dominant hand cuts while stabilized on sternum

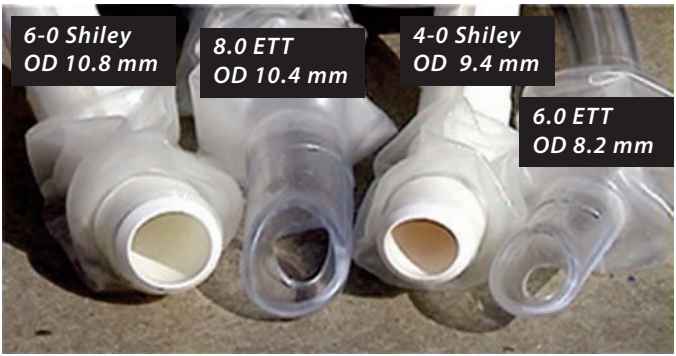
Incrementalized Approach to Cricothyrotomy

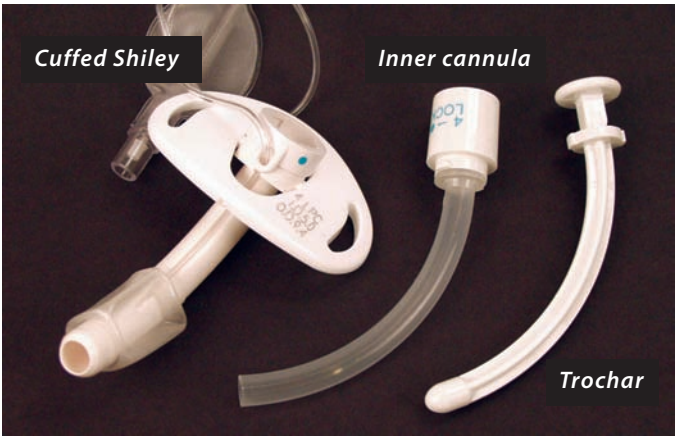

vertical cut through CTM
Stabilize larynx non-dominant hand – thumb and long finger
scapel held like pen
dominant hand cuts while stabilized on sternum
verify CTM with non-dominant index finger

Incrementalized Approach to Cricothyrotomy



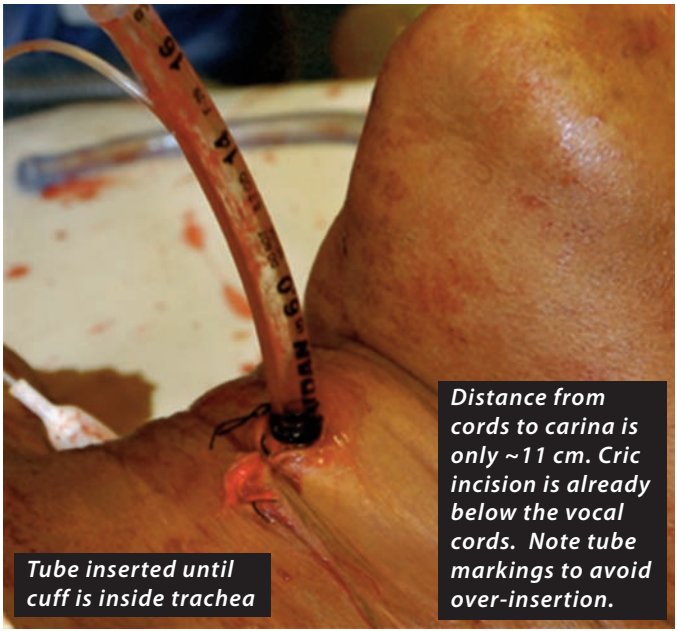
Cricothyrotomy - Tube Considerations





- Many different tubes and tracheostomy devices can be placed through cricothyroid membrane, but operators should know their outer diameters, given the relatively small size of the cricothyroid membrane (8-11 mm; smaller in females, larger in males). Shiley tracheostomy tubes (below) have an inner cannula (needed for ventilation) and a trochar (for insertion).

Surgical Airways: Post Procedure Concerns and Tracheostomy Tube Management


Tube inserted until cuff is inside trachea
Distance from cords to carina is only ~11 cm. Cric incision is already below the vocal cords. Note tube markings to avoid over-insertion.

- Air movement through tube will be evident in spontaneously breathing patient. Verify end-tidal CO2 if any concern, and listen for symmetric breath sounds. It is common to over-insert a tracheal tube which can cause hyperinflation of a lung and tracheal shift (mistakenly suggesting pneumothorax).

- Pneumothorax is not uncommon after an emergent surgical airway as air can dissect down from surgical incision.

REFERENCES BY THE AUTHOR

OTHER REFERENCES, WEBSITES, BLOGS